UNIVERSITY OF CAMBRIDGE

DEEP UNDERGROUND NEUTRINO EXPERIMENT

INTERACTION VERTEX MULTIPLICITY STUDY

28TH FEBRUARY, 2019

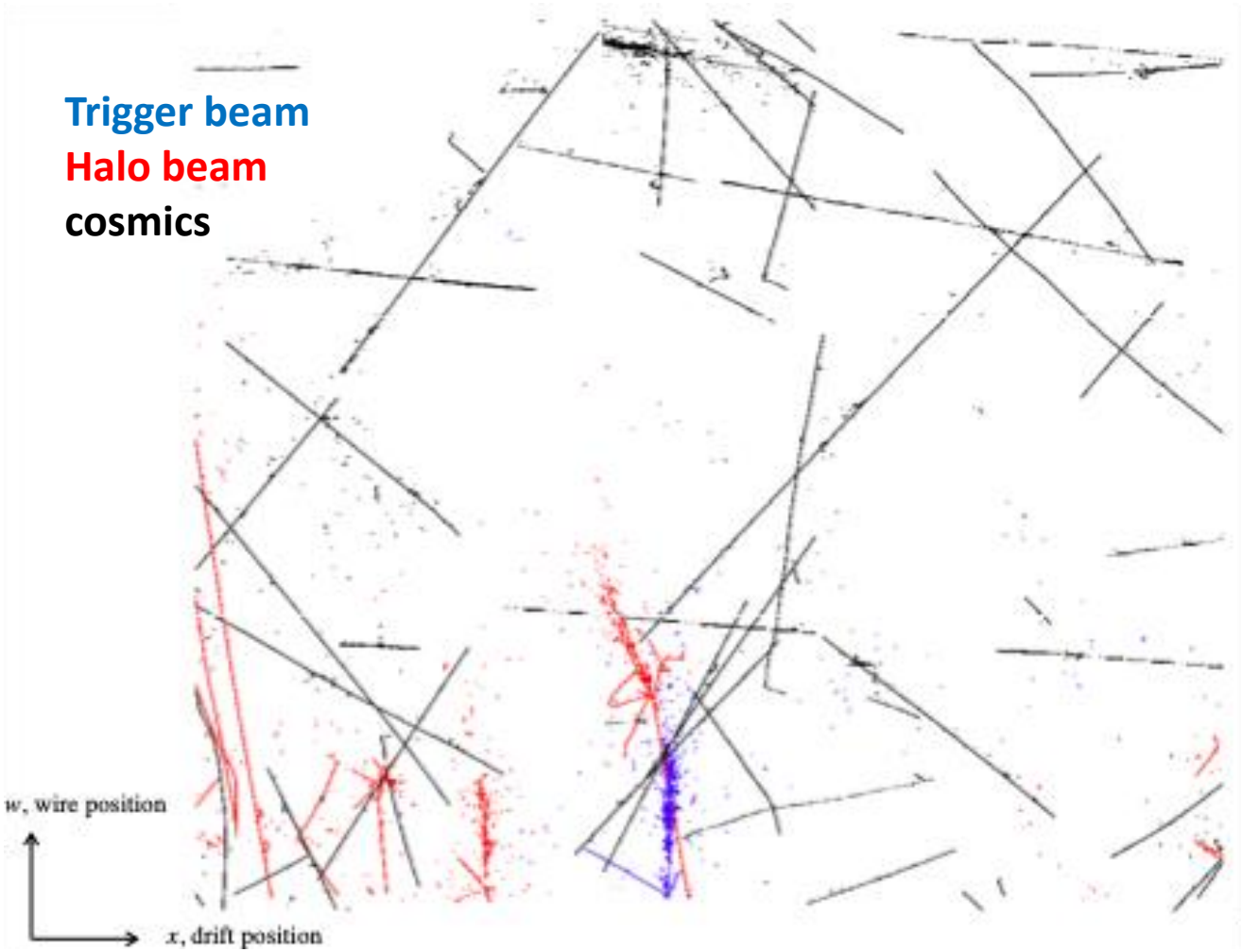
Stefano Vergani HEP GROUP – Cavendish Laboratory

OVERVIEW

- PRELIMINARY ANALYSIS OF MONTE CARLO (MC) SIMULATED EVENTS
- PRELIMINARY RESULTS OF $\pi^+ + Ar \rightarrow \mathrm{NT} + \mathrm{MS}$
- HIGH-LEVEL EFFICIENCY METRIC
- FIRST RESULTS
- FUTURE WORK

MC SIMULATIONS

- LATEST VERSION: mcc11 ~27260 events
- At this stage halo beam and cosmics have been removed
- SpaceCharge: space charge effect on (not FluidFlow)
- Momenta ranging from 1 to 7 GeV



MC SIMULATIONS: WHICH INFORMATION TO EXTRACT

To every mc particle many pieces of information are associated: energy, momentum, number of daughters, number of calohits produced, process for the production, etc.
The first part of the analysis consisted in finding which information is useful to this study. It turned out to be: particle data group (pdg) code, number of daughters (granddaughters etc.) and all information associated to the daughters, number of hits produced in the detector.

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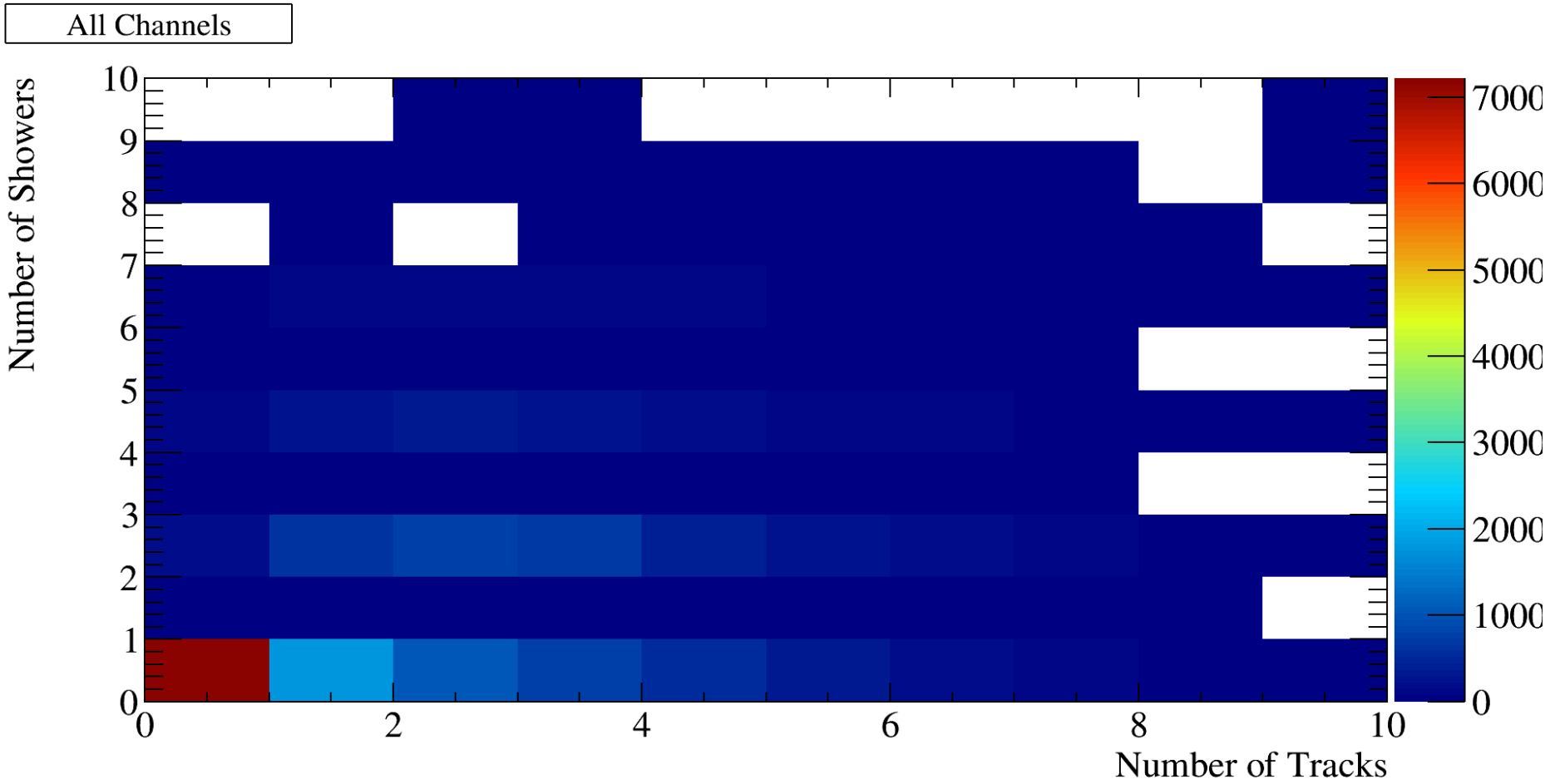
Looping over the daughters of each trigger particle we look for the number of tracks and showers. Every daughter with pdg code 11, -11, 22 is defined as "shower", otherwise as track. What we want to obtain are constants M and N for $\pi^+ + Ar \rightarrow NT + MS$

TRIGGER PARTICLES

TRIGGER PARTICLE	COUNTS
π^+	8591
e^+	6515
p	2169
K^+	427
μ^+	214
TOTAL	17916

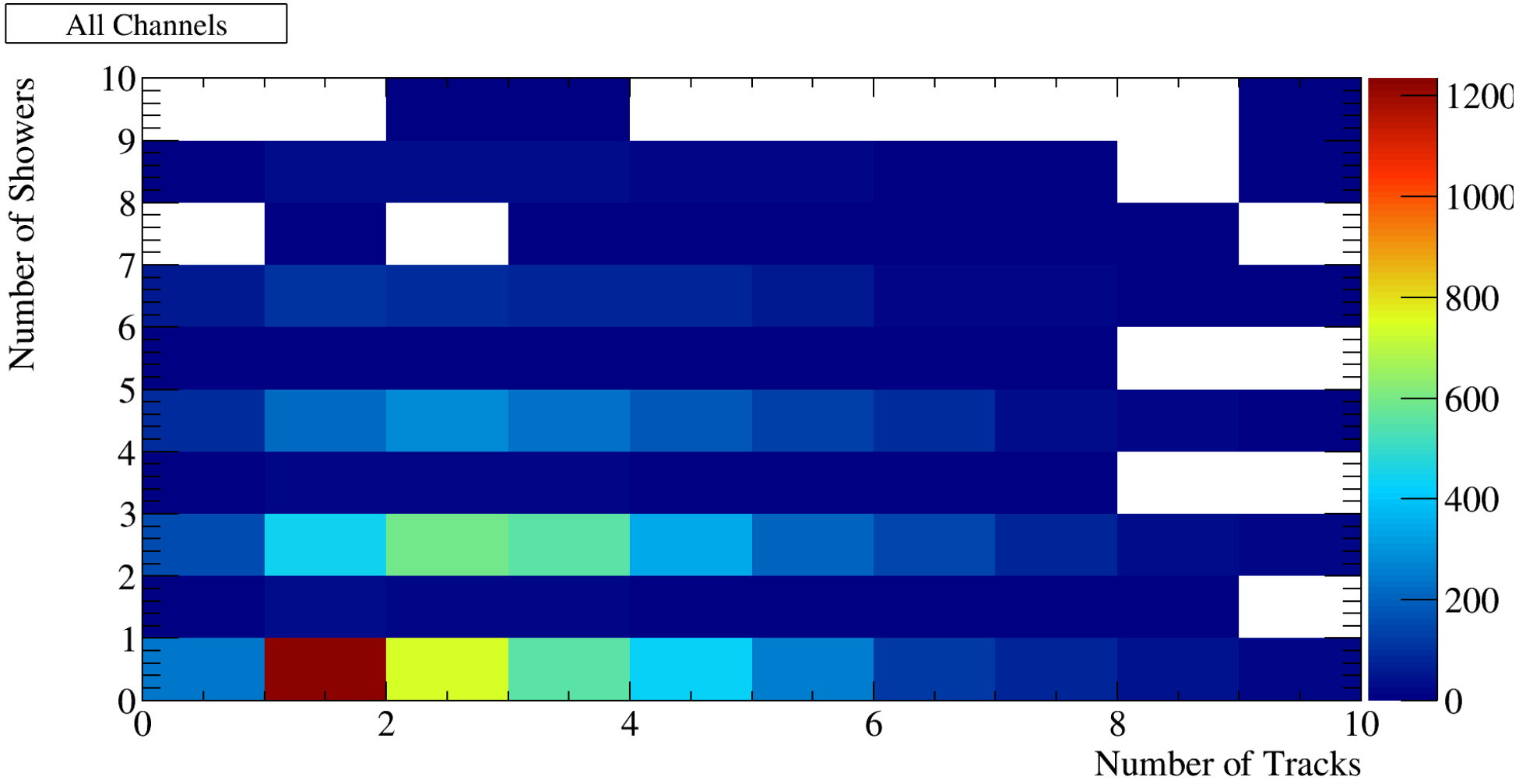
NON-REFINED RESULT – ALL ENERGIES / ALL TRIGGER PARTICLES

Daughter showers and daughter tracks



NON-REFINED RESULT – ALL ENERGIES / π^+ AS TRIGGER

Daughter showers and daughter tracks

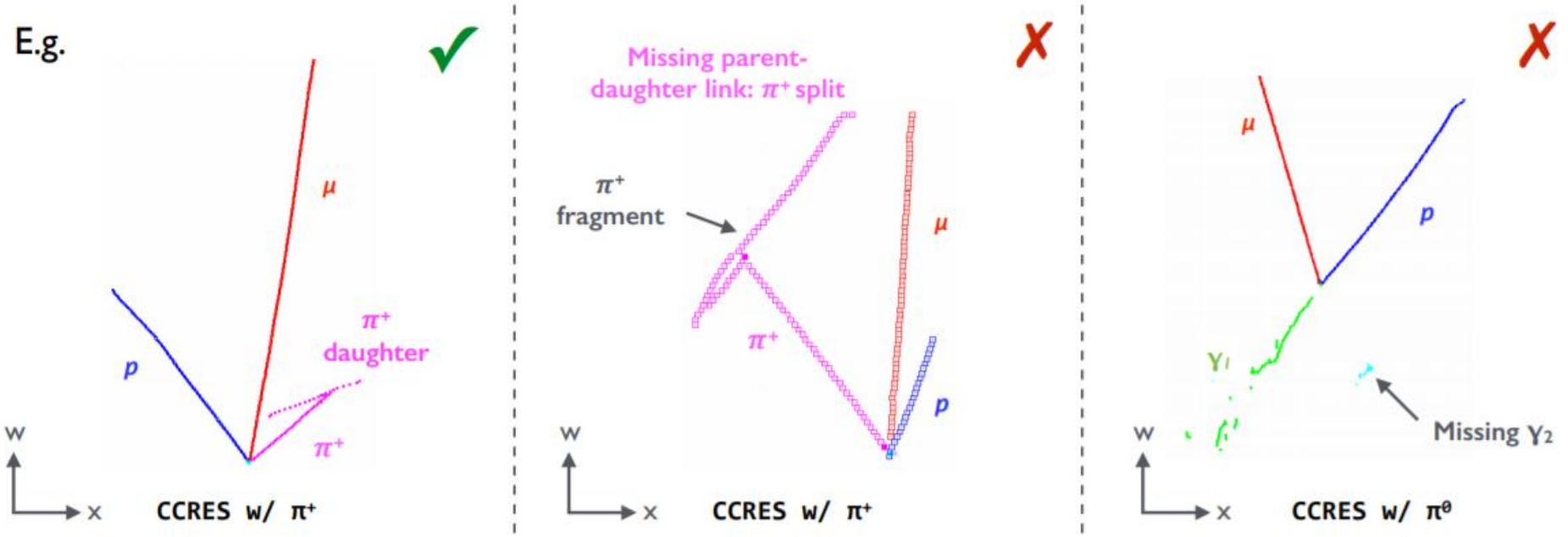


PANDORA RECONSTRUCTION METRICS FOR MICROBOONE

- To assess performance for simulated MicroBooNE events, used selection of event topologies
- Examine fraction of events deemed “correct” by very strict pattern-recognition metrics:

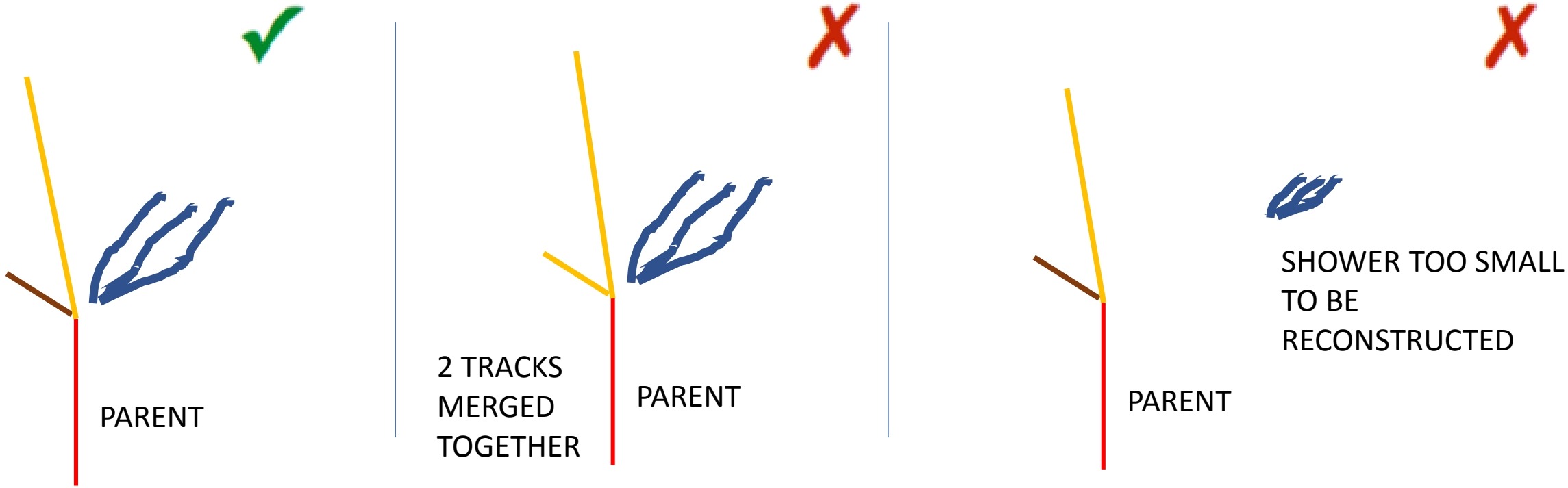
✓ consider exclusive final-states where all true particles pass simple quality cuts (e.g. nHits)

✓ Correct means exactly one reco primary particle is matched to each true primary particle

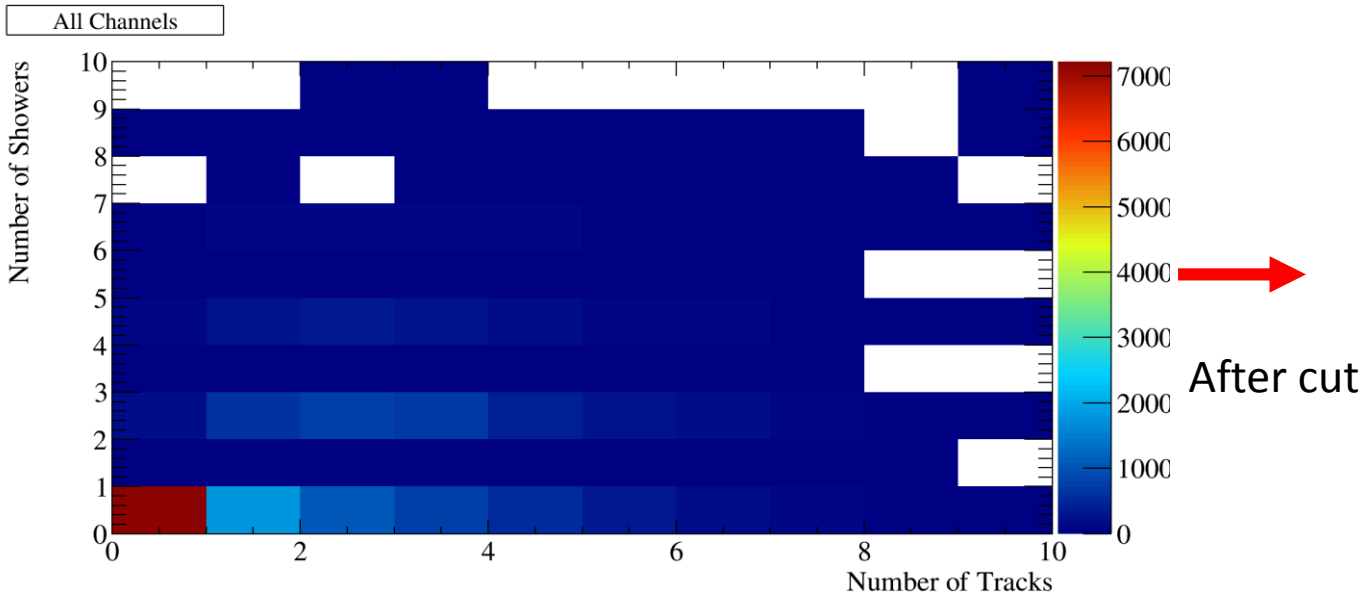


MODIFIED RECONSTRUCTION METRIC

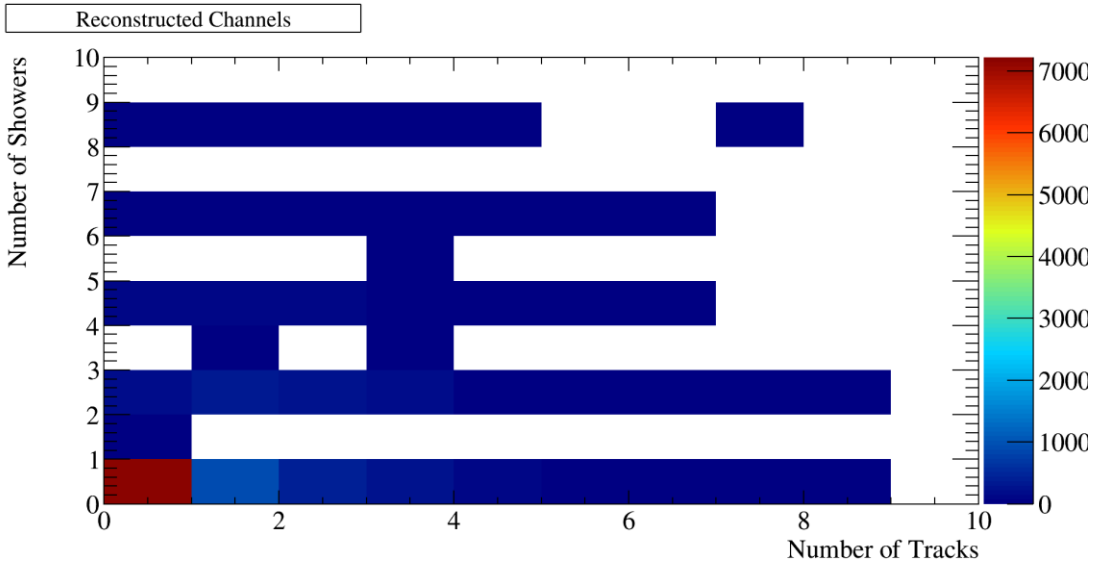
- Aiming to characterize quality of hierarchy information
- Defining “good reconstruction” as having all daughter mc particles from primary pion interaction associated to a unique pfparticle
- **Once a pfp gets associated to one mc particle, the same pfp cannot be associated to another mc particle**



RECONSTRUCTED – ALL ENERGIES / ALL TRIGGER PARTICLES

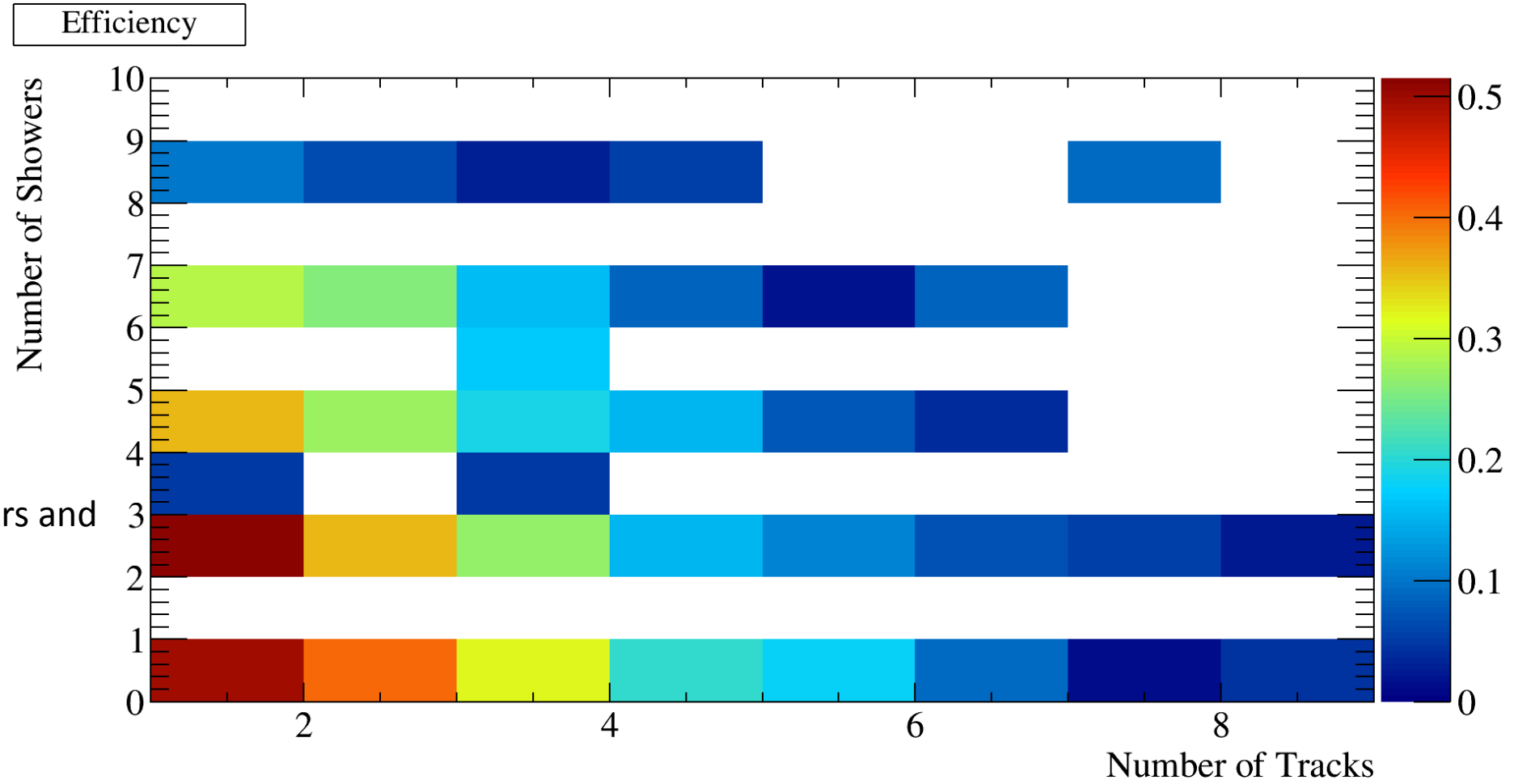


After cut

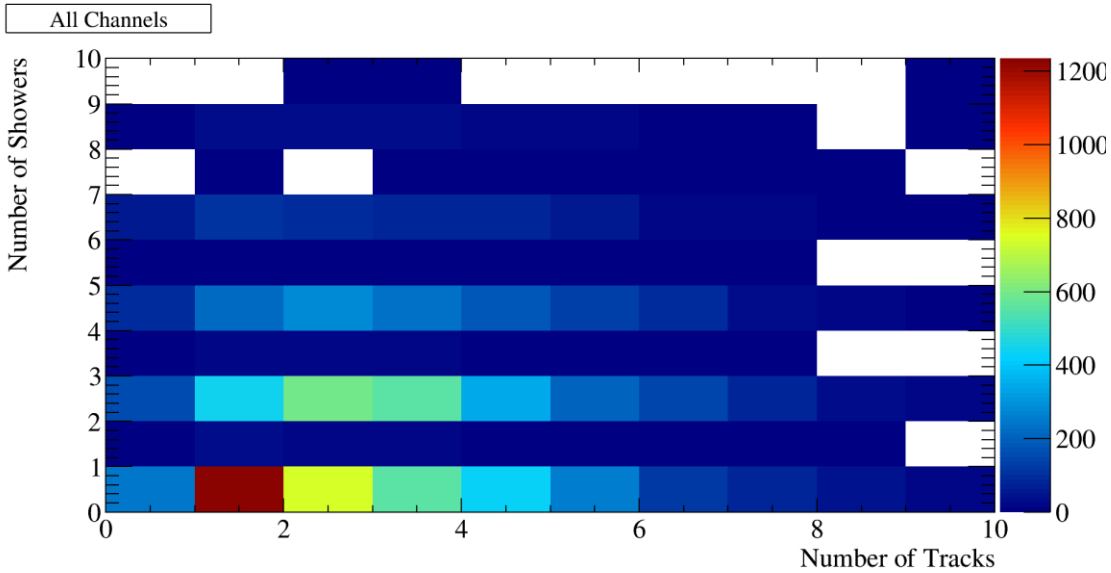


EFFICIENCY – ALL ENERGIES / ALL TRIGGER PARTICLES

Daughter showers and daughter tracks



RECONSTRUCTED – ALL ENERGIES / π^+ AS TRIGGER



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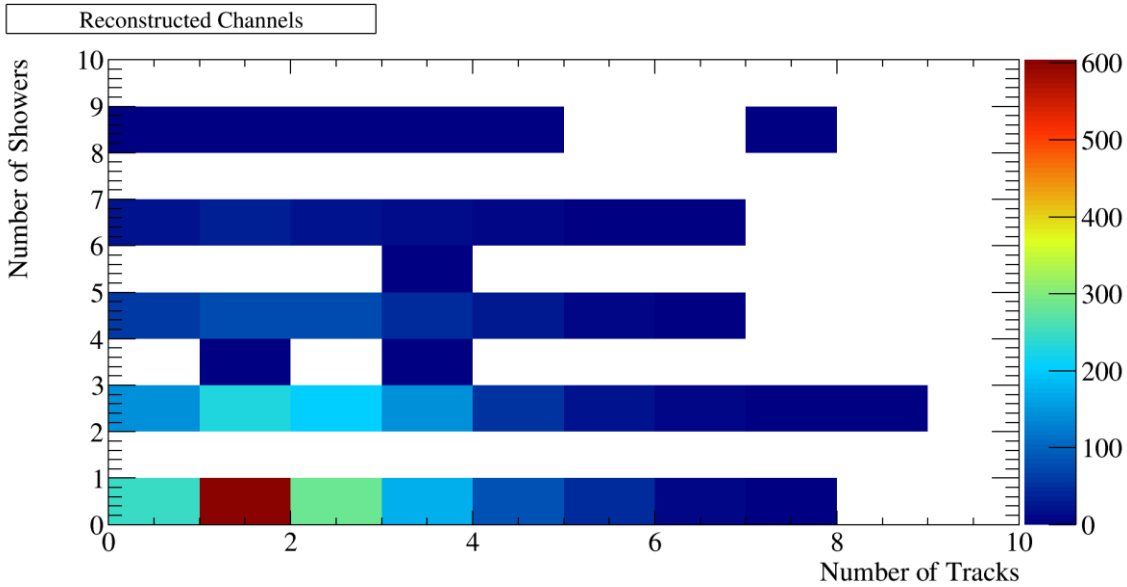
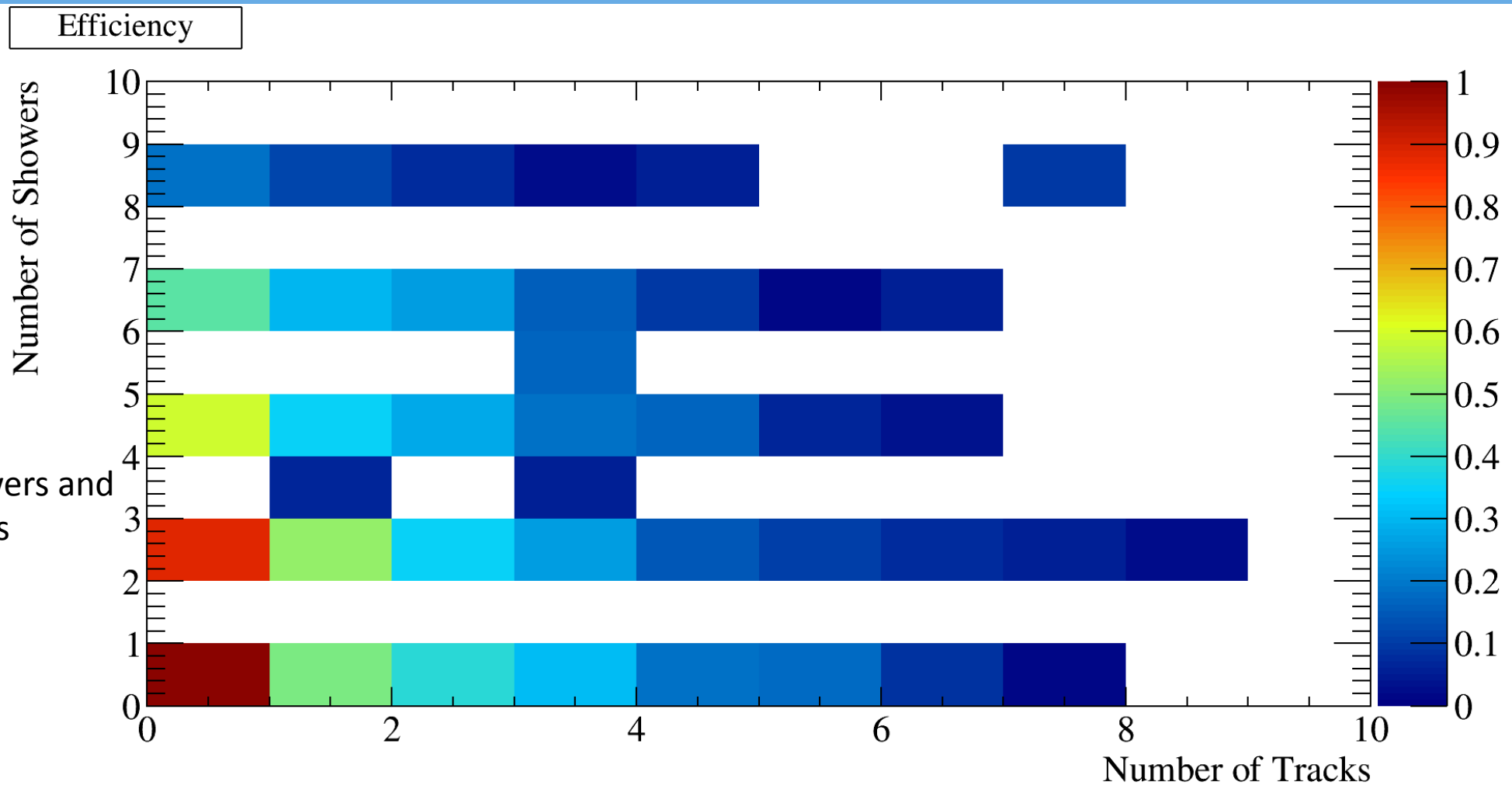
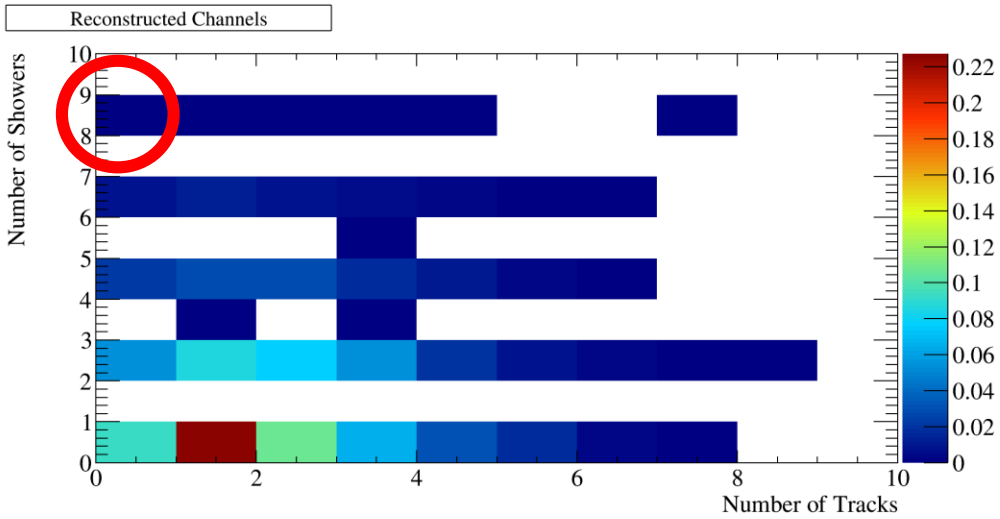


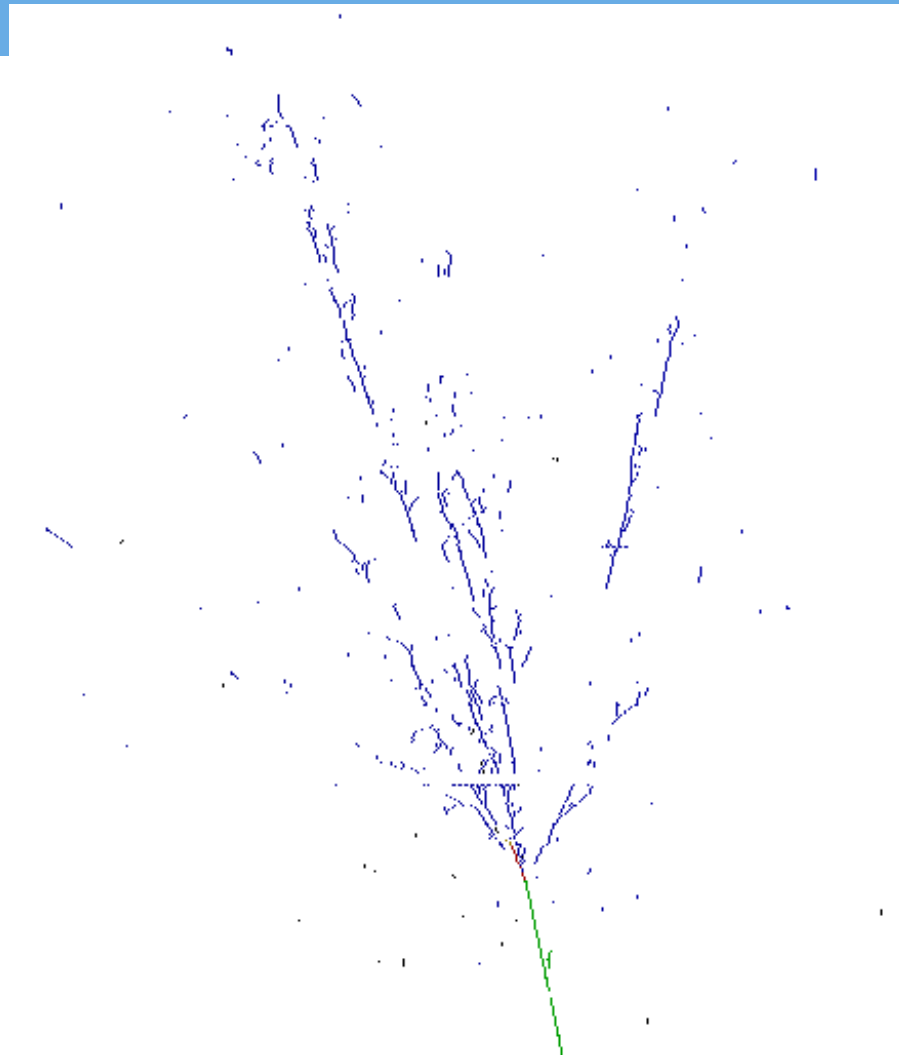
EFFICIENCY – ALL ENERGIES / π^+ AS TRIGGER

Daughter showers and daughter tracks



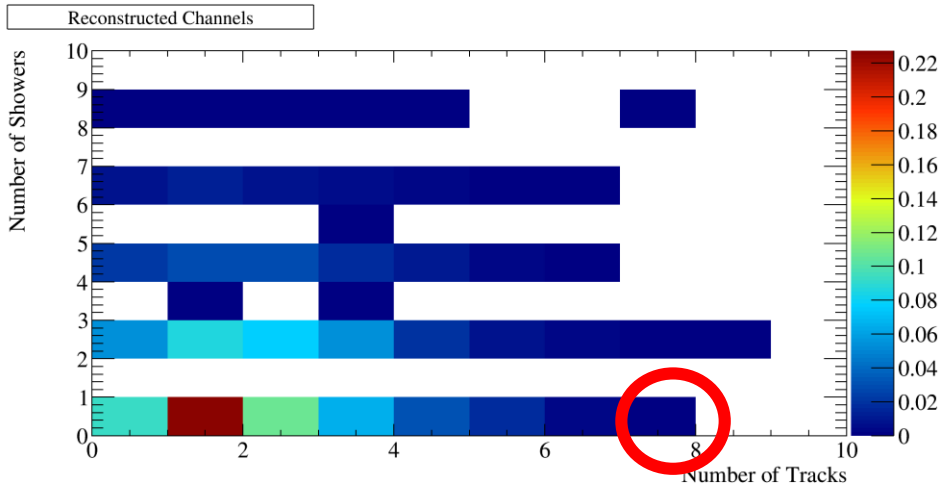
π^+ AS TRIGGER – 0 TRACK 8 SHOWERS

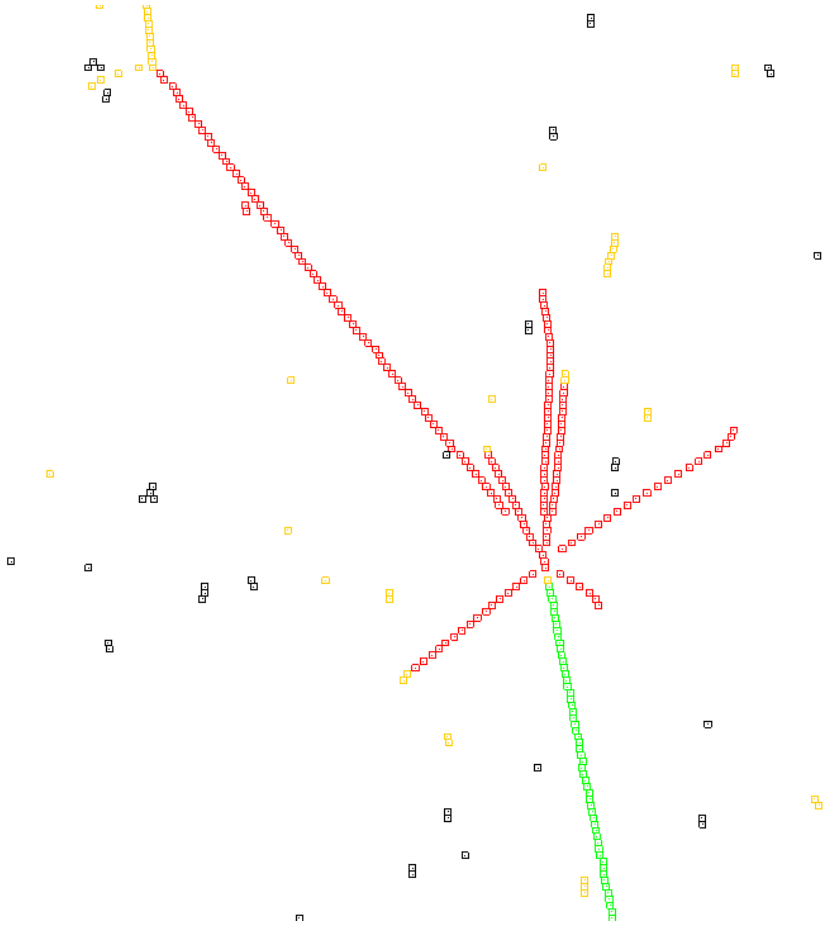




BLUE SHOWER DAUGHTER
GREEN TRIGGER π^+
RED TRACK DAUGHTER
ORANGE GRANDDAUGHTER
BLACK OTHER

π^+ AS TRIGGER – 7 TRACKS 0 SHOWER





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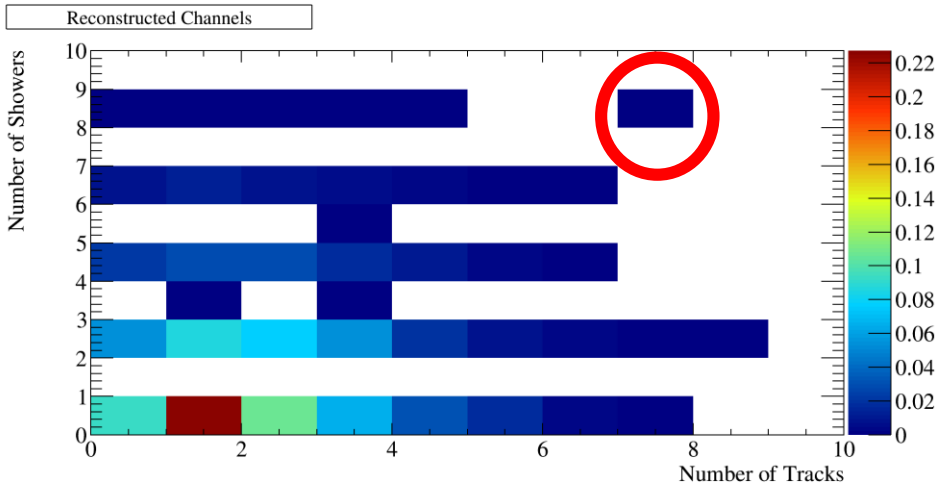
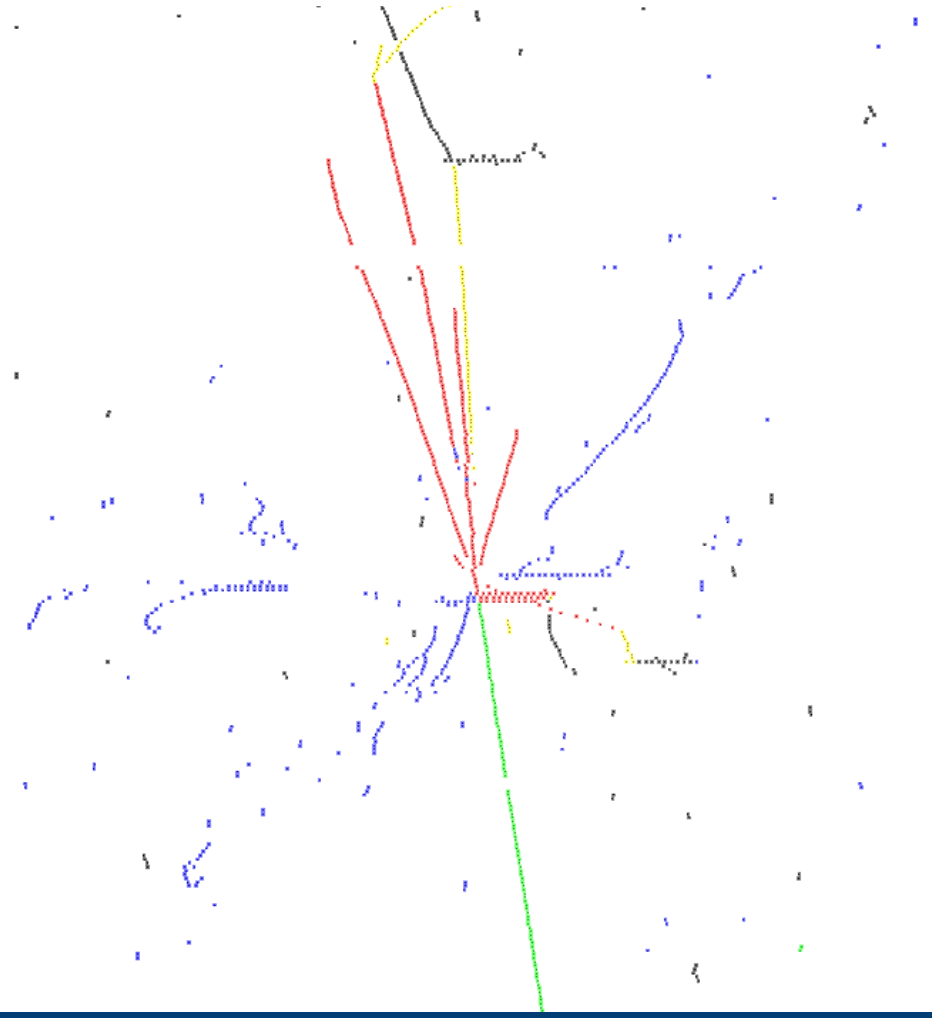
π^+ AS TRIGGER – 7 TRACKS 8 SHOWERS





BLUE SHOWER DAUGHTER

GREEN TRIGGER π^+

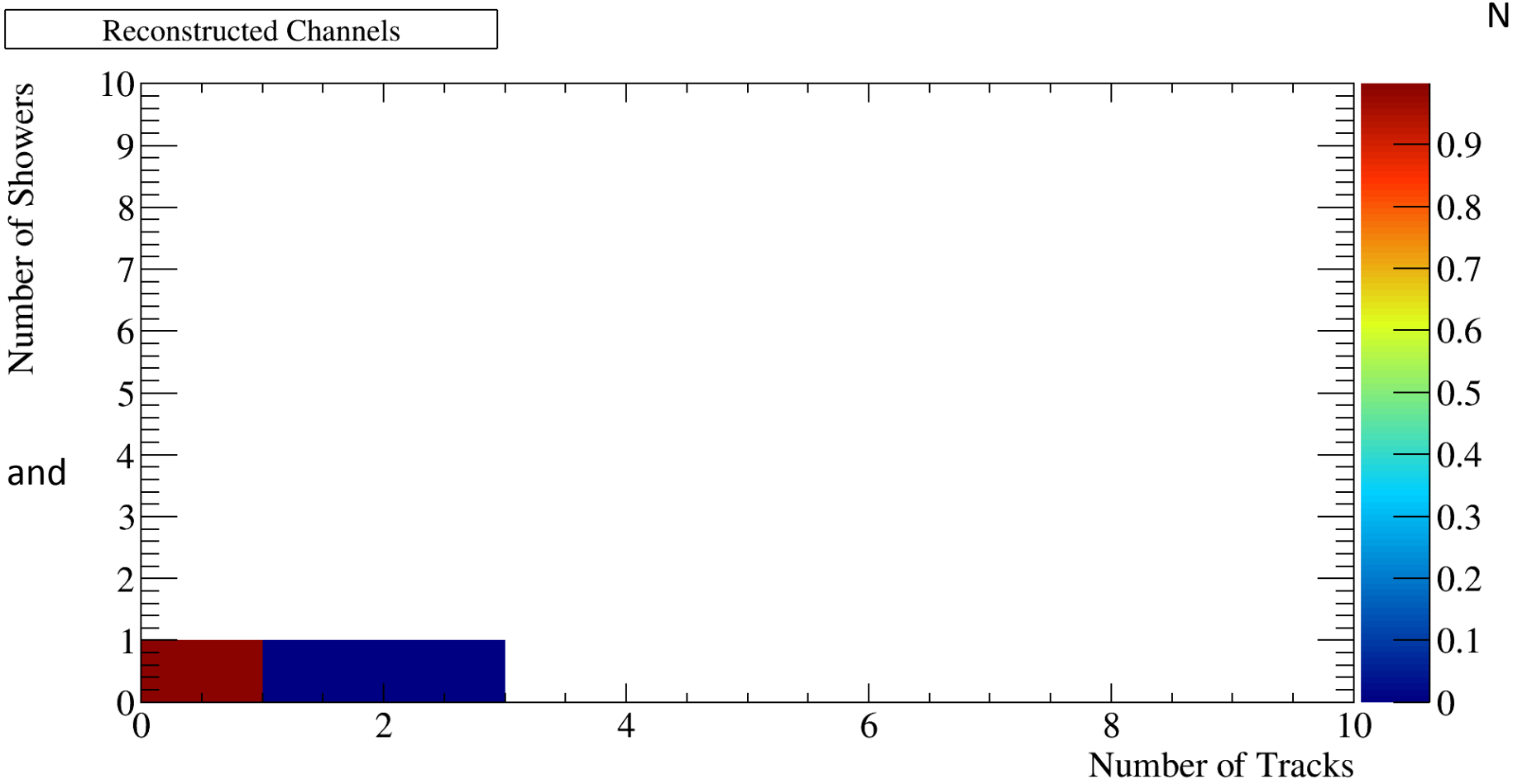
RED TRACK DAUGHTER

ORANGE GRANDDAUGHTER

BLACK OTHER

RECONSTRUCTED – ALL ENERGIES / e^+ AS TRIGGER

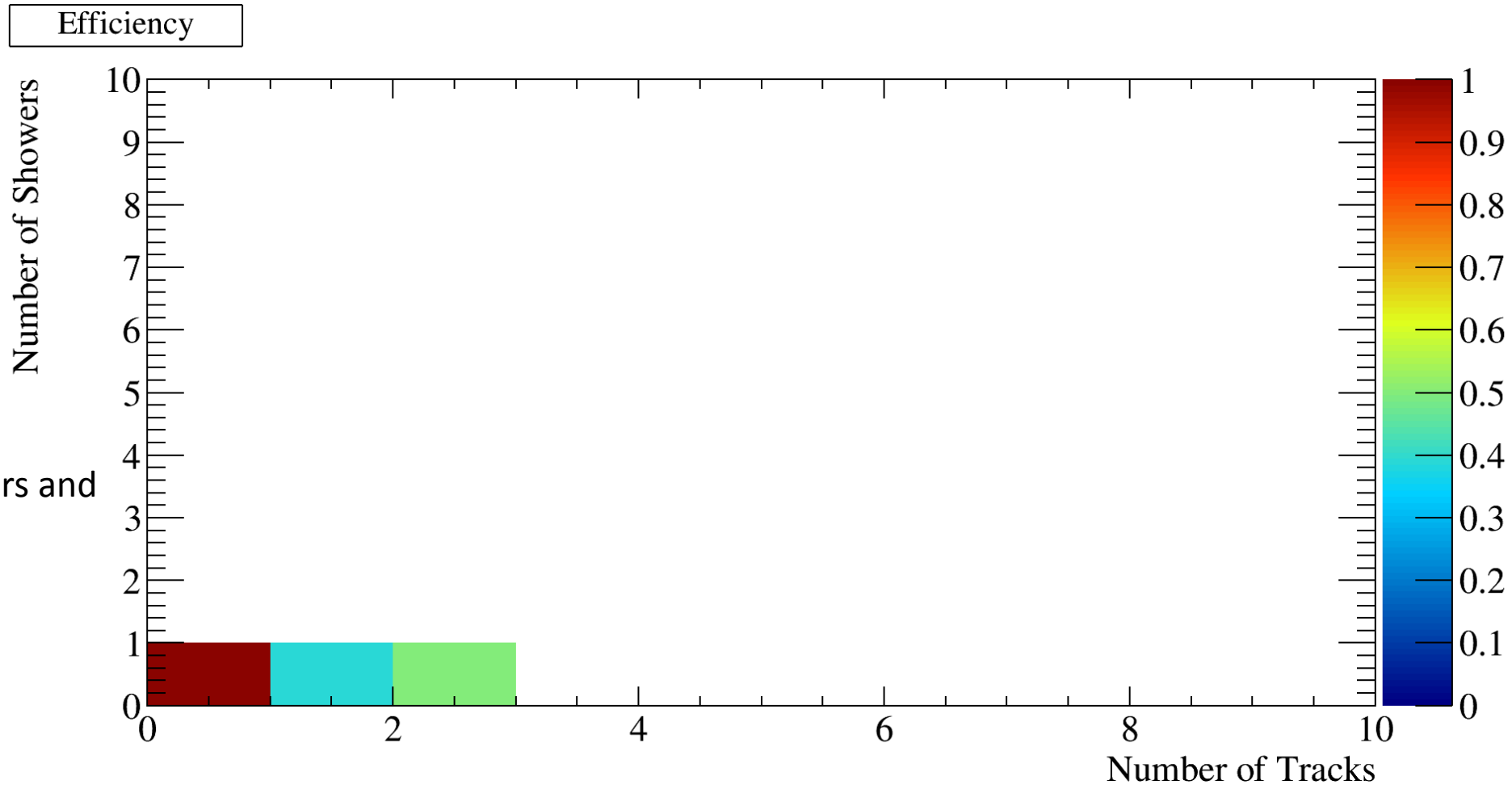
NORMALISED TO 1



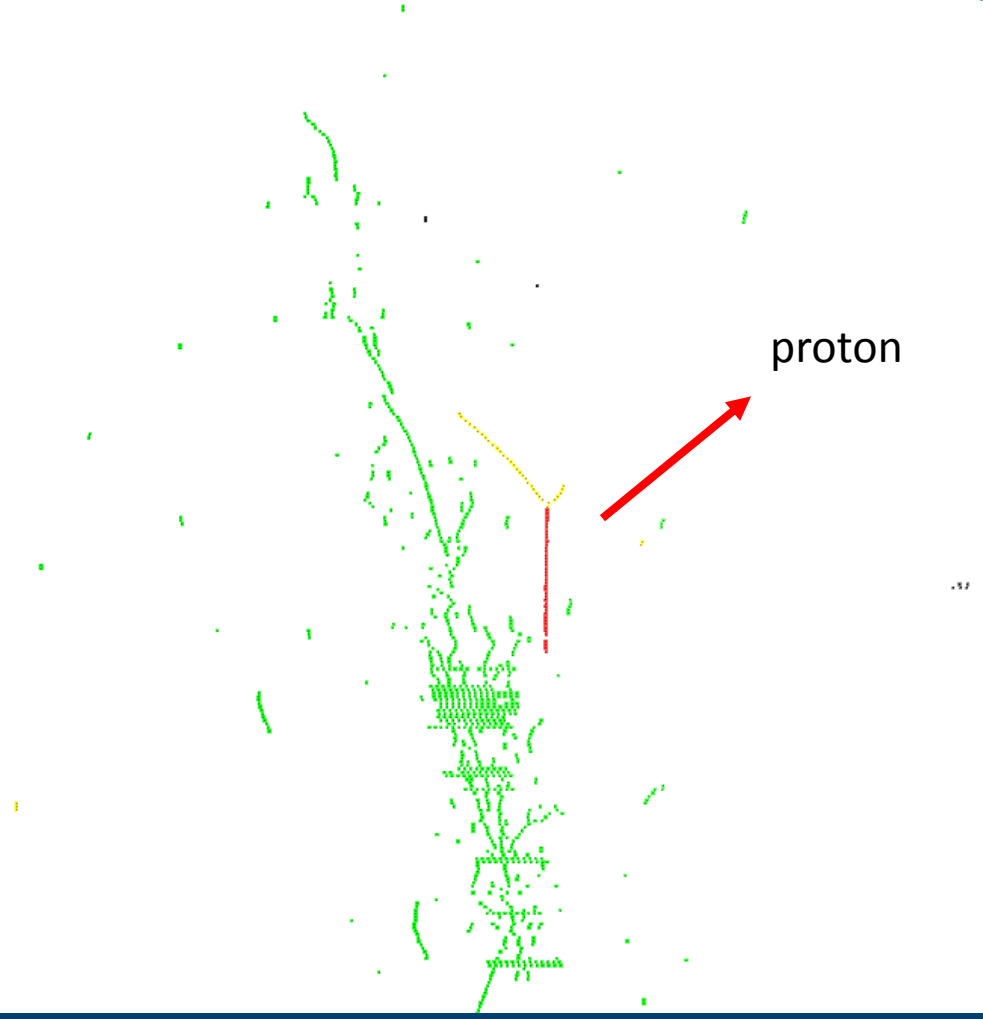
Daughter showers and daughter tracks

EFFICIENCY – ALL ENERGIES / e^+ AS TRIGGER

Daughter showers and daughter tracks



e^+ AS TRIGGER – 1 TRACK 0 SHOWER



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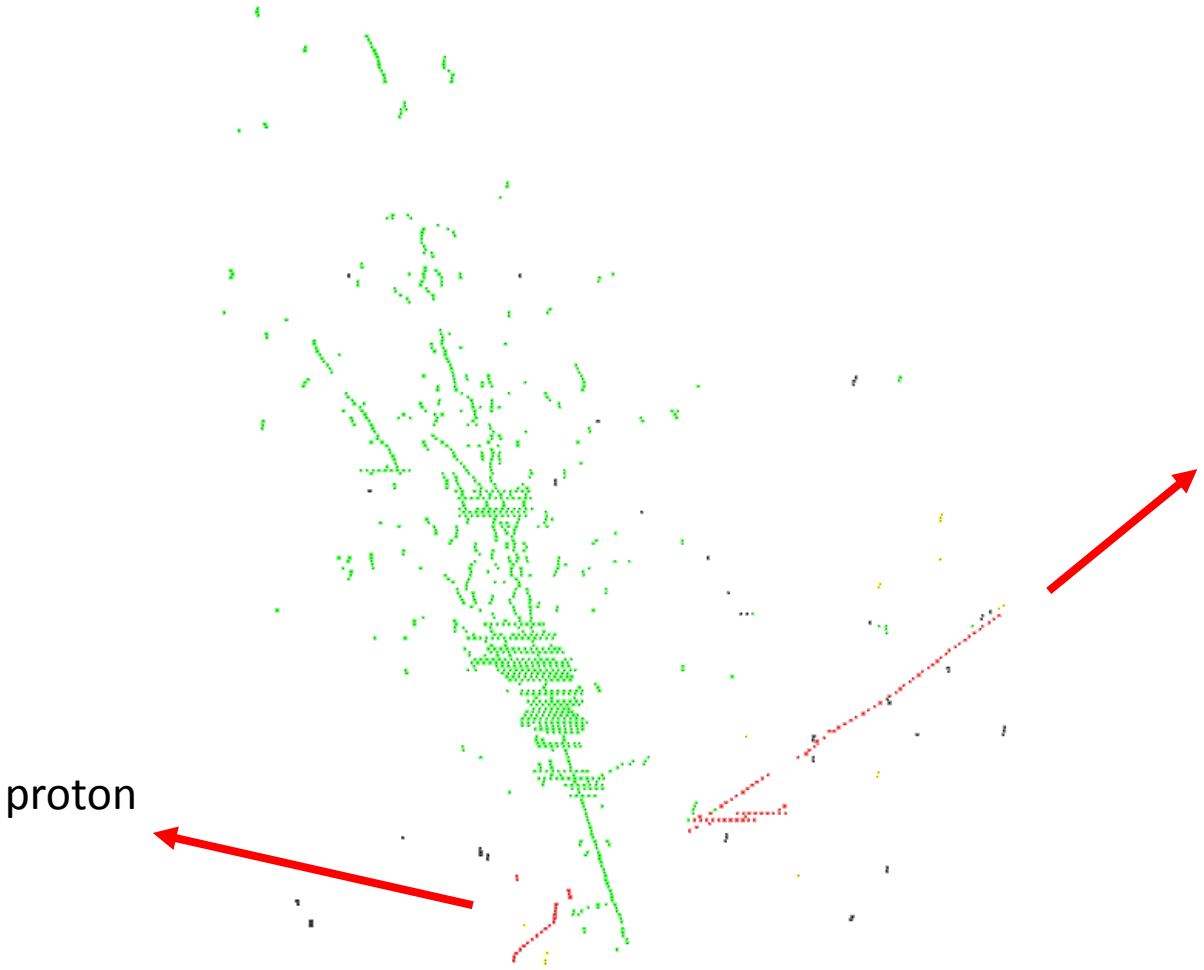
ORANGE GRANDDAUGHTER
BLACK OTHER

e^+ AS TRIGGER – 2 TRACKS 0 SHOWER



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RESULTS AND FUTURE PLANS

- Preliminary studies on mc simulated events in ProtoDUNE-SP suggest that the most probable channel is $\boldsymbol{\pi^+ + Ar \rightarrow 1T + 0S}$ with a reconstruction efficiency of ~ 50%.
- Next step will be to study the effect of halo particles, cosmic rays, and beam momentum to increase the level of accuracy.
- After that we will analyse data from ProtoDUNE-SP searching for a correspondence with the simulations.
- From there we will refine the analysis identifying in the simulations as well as in the data the particles involved in the interaction.

THANK YOU FOR YOUR ATTENTION

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BACKUP SLIDES

FURTHER MATCHING CUTS

Moreover, we added the following 3 further cuts:

1. To be considered, the pfp must share at least 15 hits with the mc particle (W, V, and U wire plane)
2. Photons produced more than 2.5 cm away from the first interaction are not considered
3. Neutrons that travel long distances in the detector are not considered as well