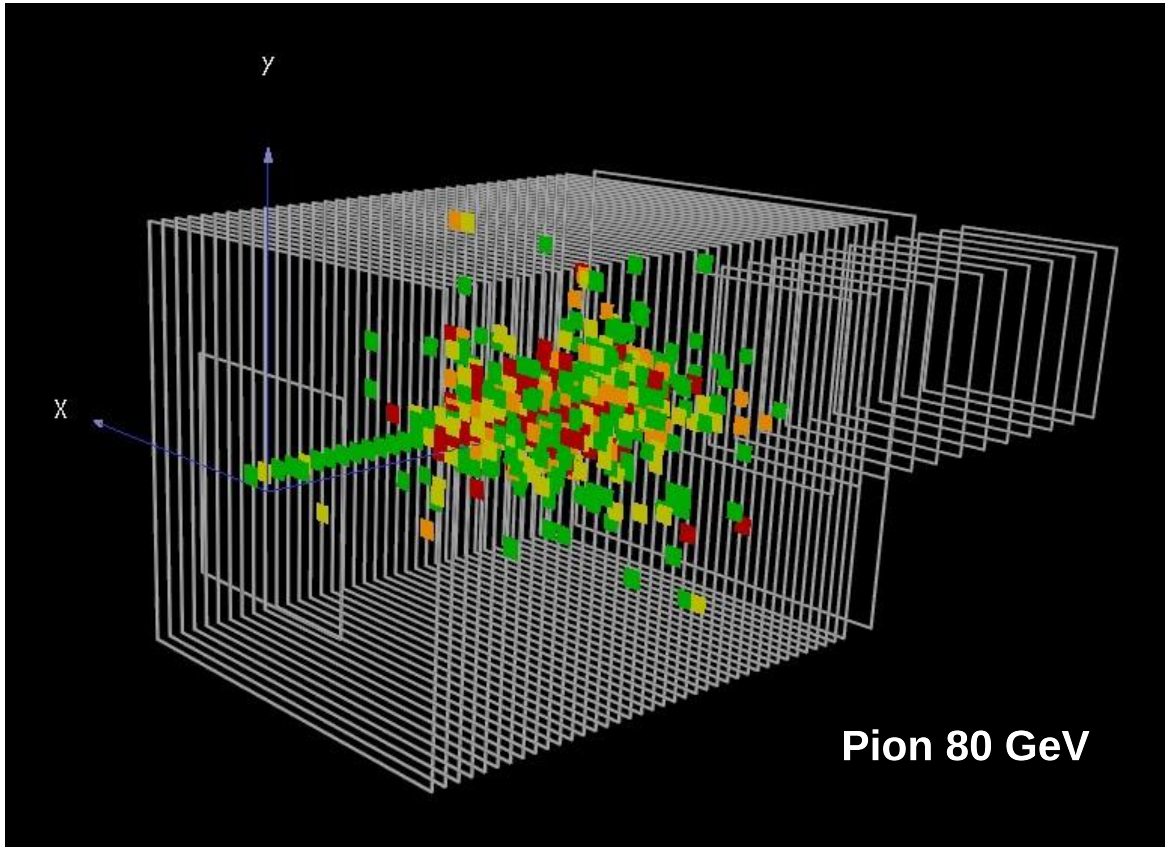
NEUTRON STUDY TOWARDS ISOLATION LEVEL



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AHCAL Main Meeting

DESY, 16th December 2019

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

CALICE

Universität Hamburg DER FORSCHUNG | DER LEHRE | DER BILDUNG

DESY.

Outline

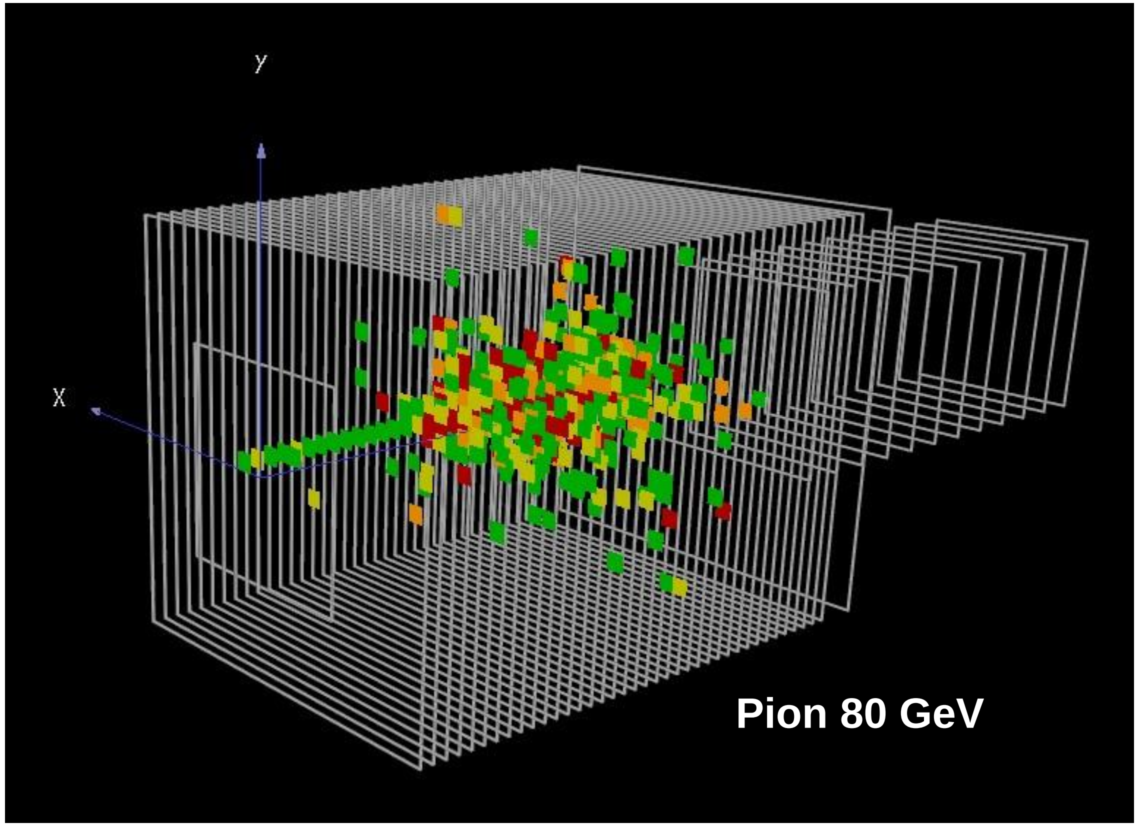
- Motivation & introduction
- Neutronness definition
- Isolation definition
- Time & energy distributions
- Summary and outlook

Motivation

Need for neutron study

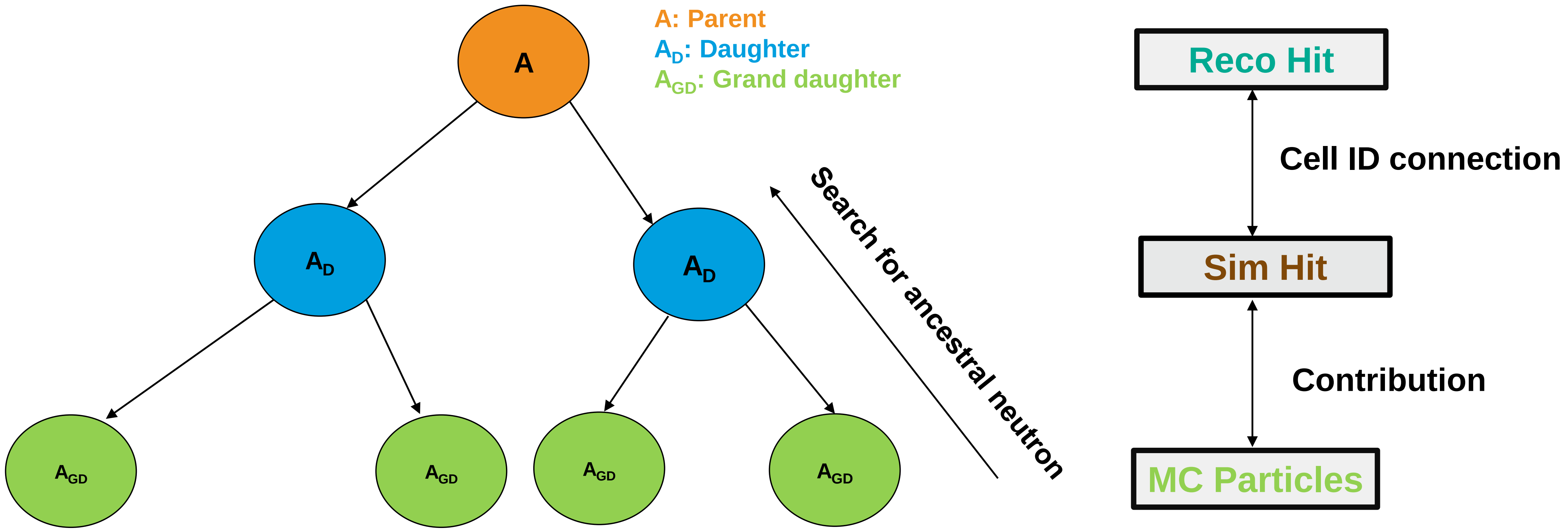
- In showers there are isolated hits – we assume they are neutrons. Is that true?
- What is the effect on energy and timing?

  → Investigate correlations!
- Remove isolated neutrons in order to reduce confusion, in particular late neutrons.
- What is the impact of after-glow contaminating later events?



Introduction

- Trace all the particles in the shower and extract the properties of the MC particles (energy, momentum, PDG and time stamps).
- A relation between the **Reco Hit** and the **Sim Hit** is built which gives all the **MC particles** contributing to that hit.

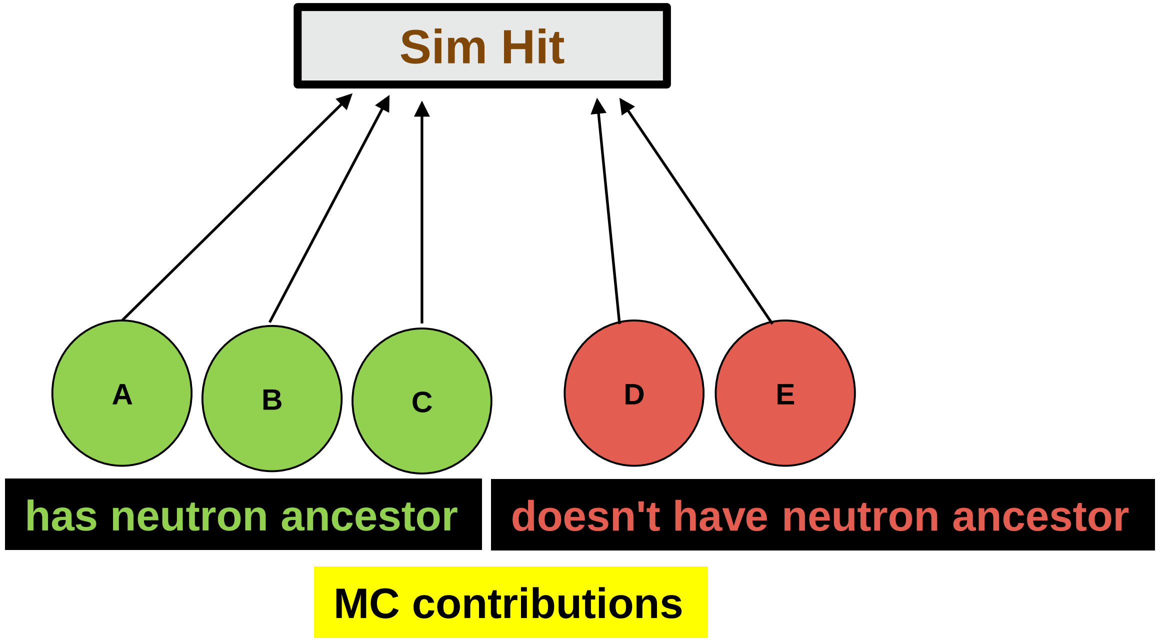


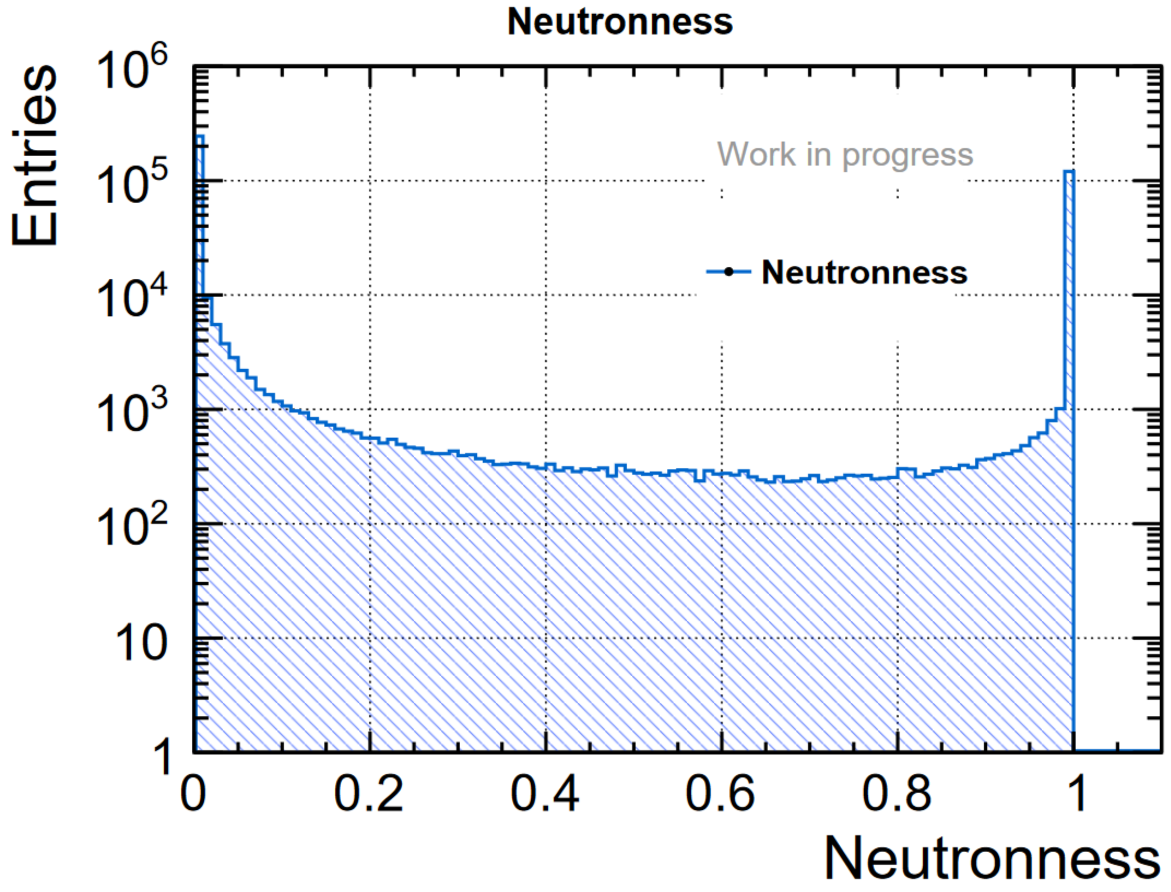
Neutronness

Neutronness is defined as the energy-weighted contributions of MC particles with a **neutron ancestor** compared to all contributions to the Sim hit.

$$\text{Neutronness(hit)} = \frac{\sum_{contribution:neutron\ ancestor} Energy(contribution)}{\sum_{contribution} Energy(contribution)}$$

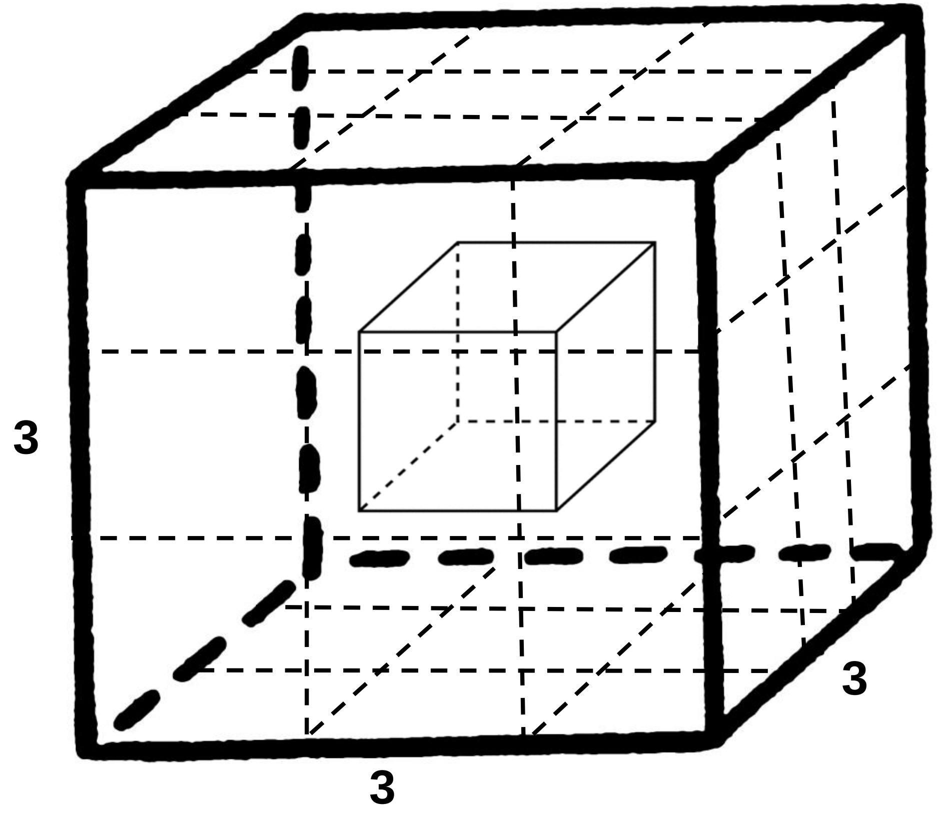
Define fraction cut, e. g. neutronness > 0.9 to call a hit “from a neutron”.





Definition of Isolation level

Compares the energy of a hit to the energy of its **neighbours.**

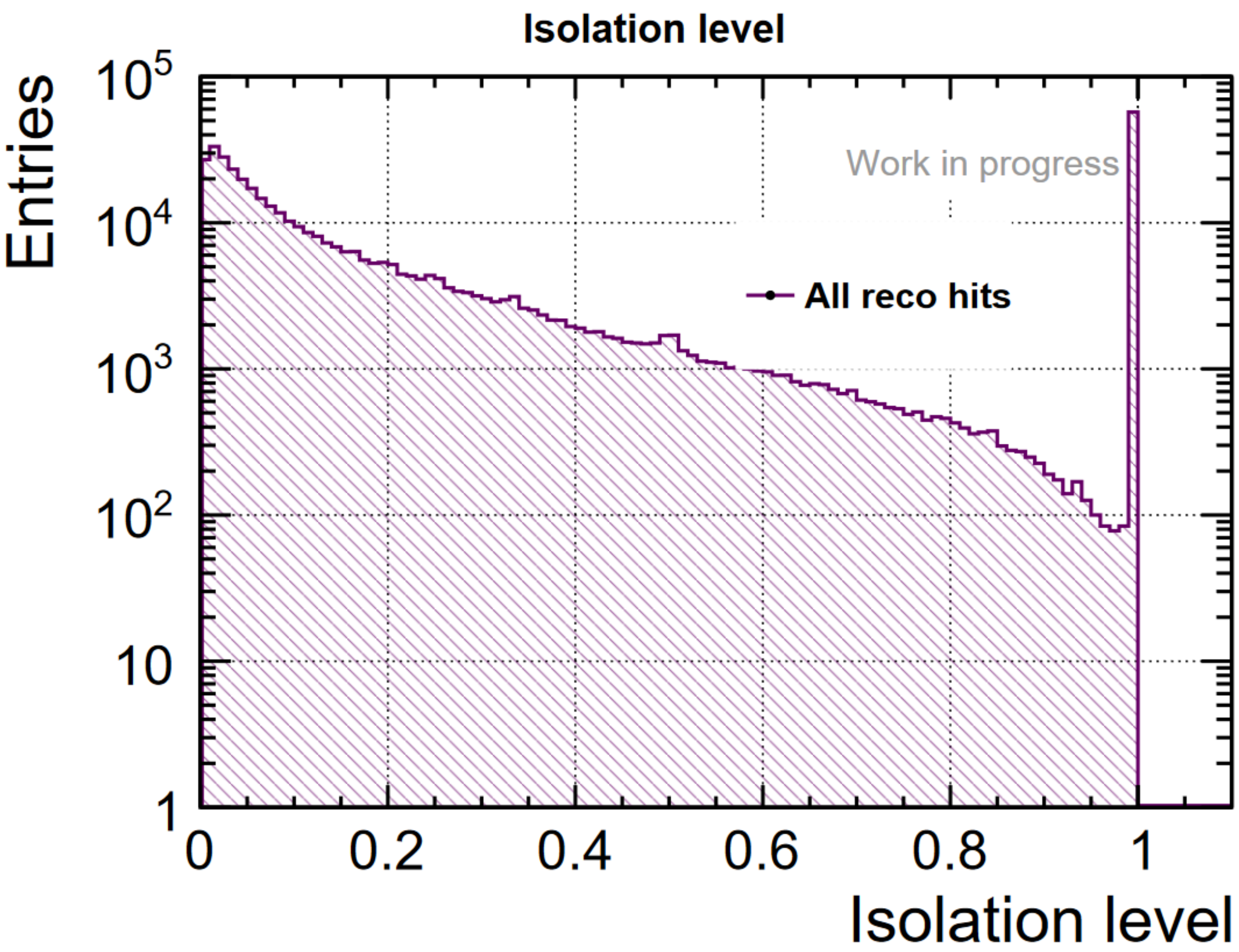


$$\text{Isolation level} = \frac{\text{Energy of hit}}{\text{Energy sum of all neighbours (all hits in 3 x 3 x 3 box)}}$$

Isolation level

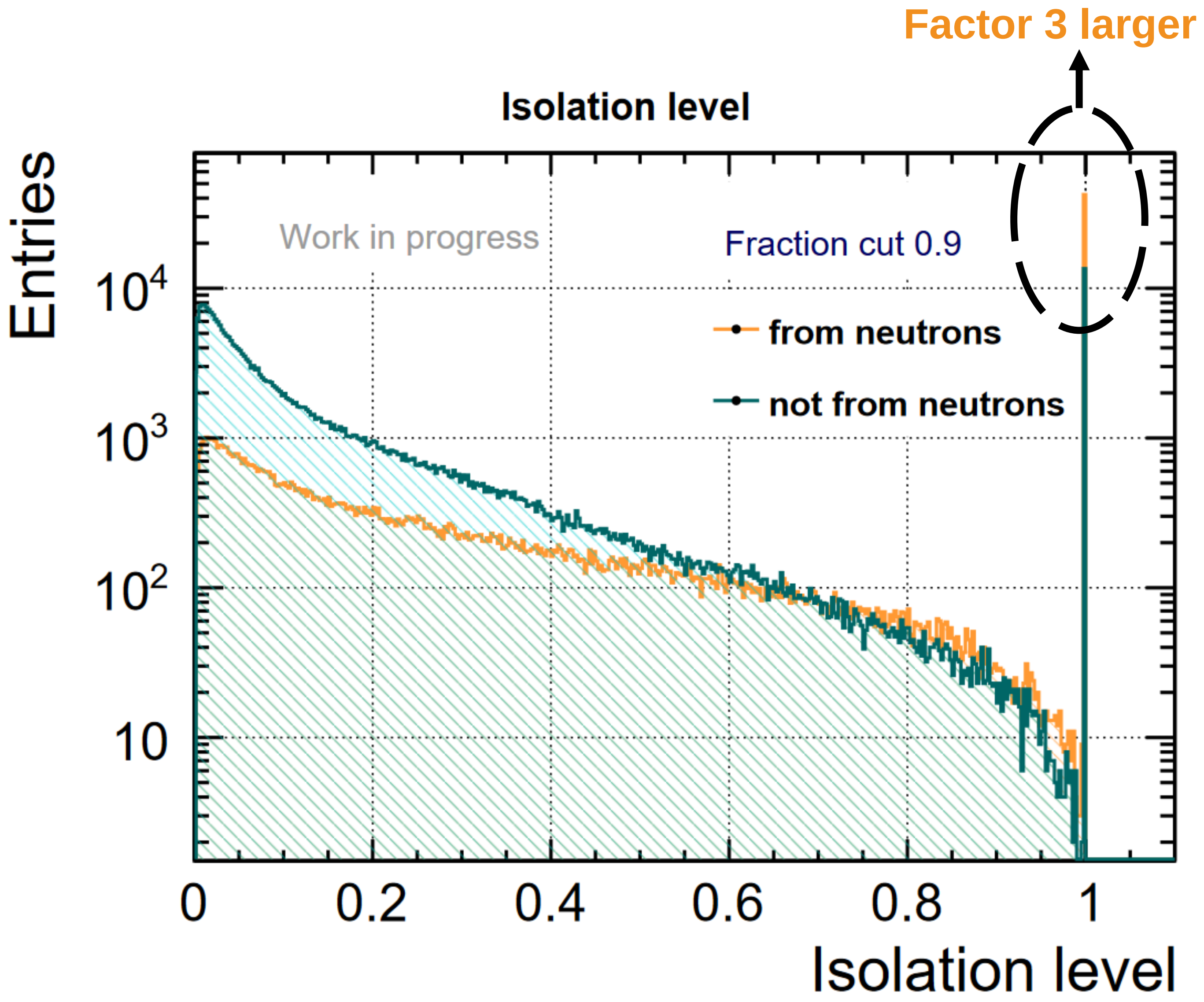
- Vast majority of Reco hits lie in the dense shower with low level of isolation.

- There is a peak at 1. These hits are **fully isolated**.



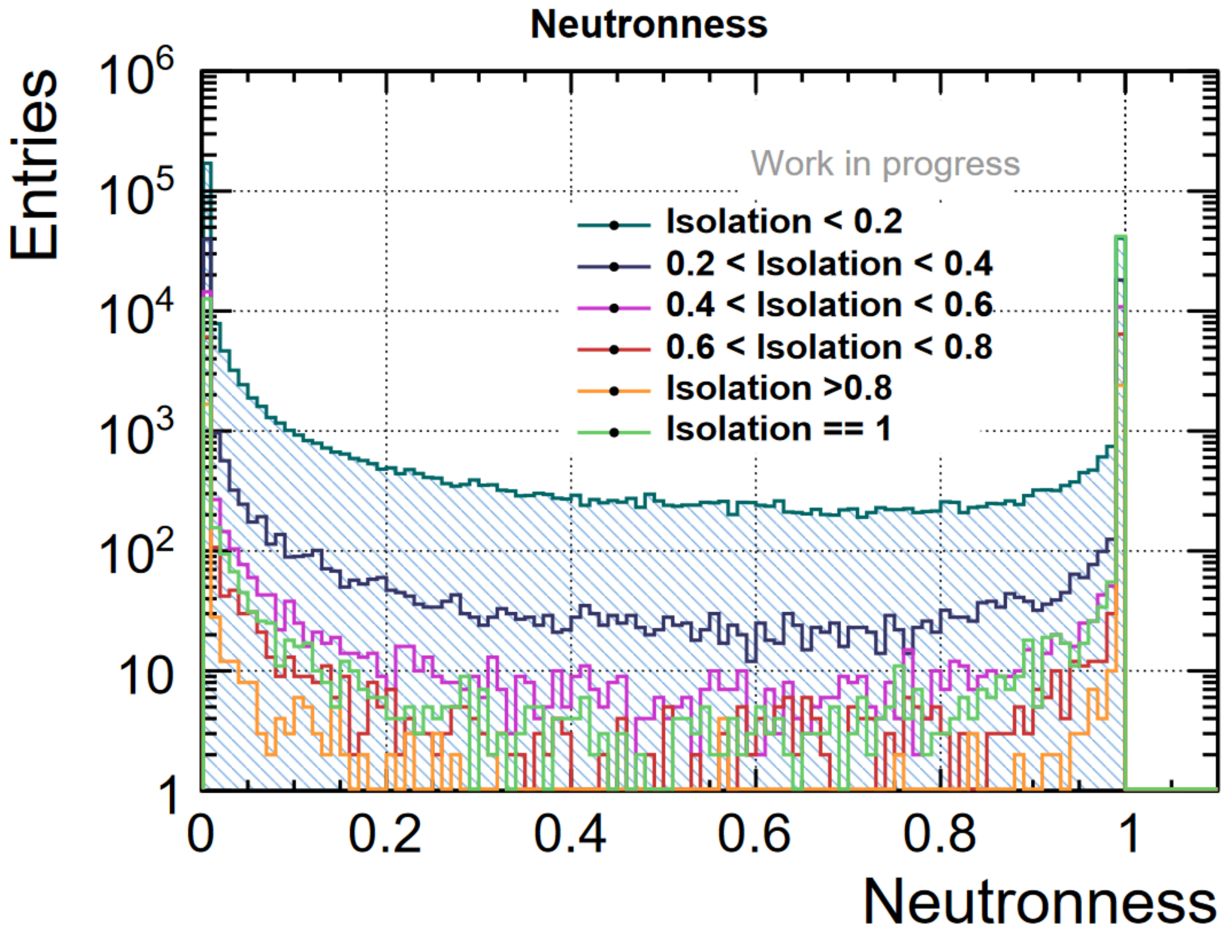
Isolation level

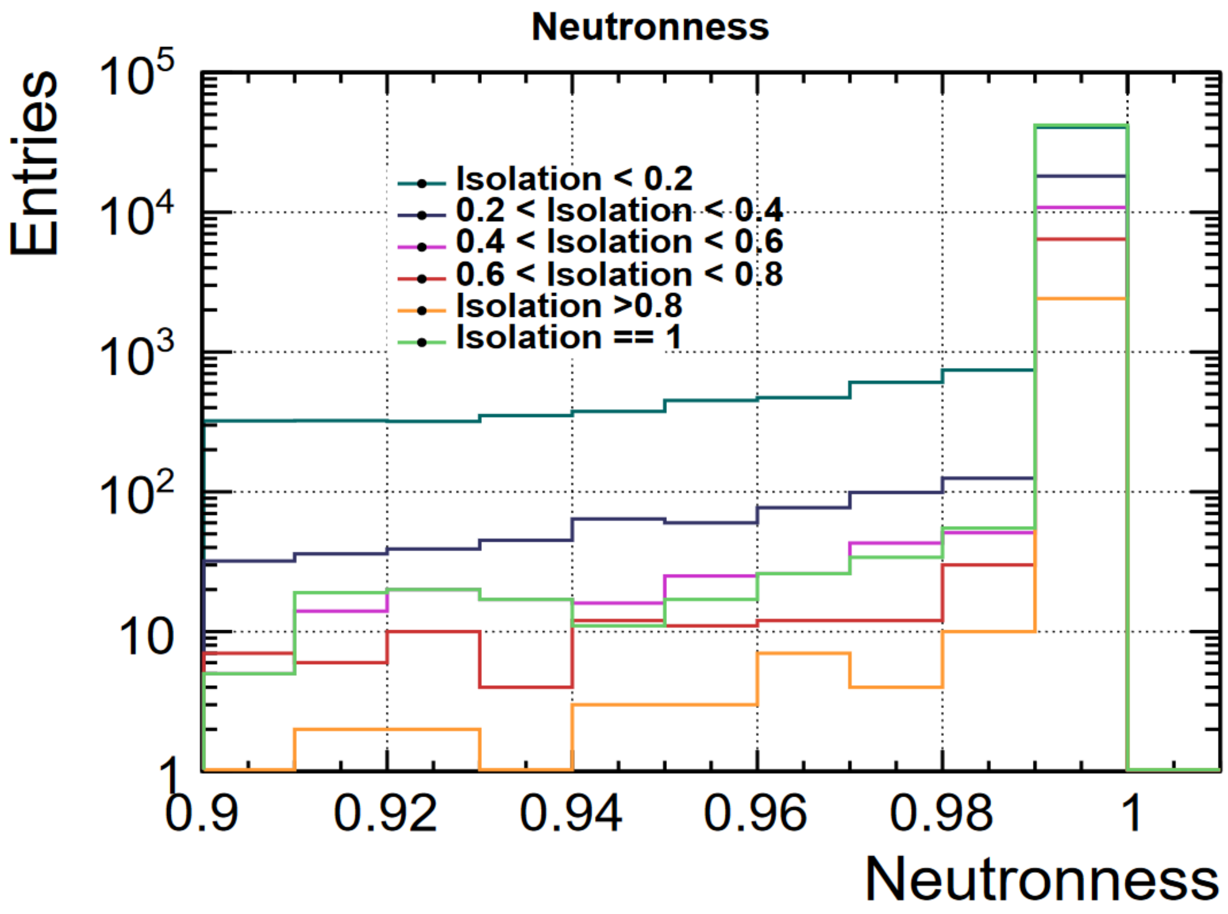
- Clear correlation with neutronness:
  - At isolation equal to 1,
    75 % of hits are from neutrons.
- Use isolation to identify neutrons!



Neutronness for different isolation levels

- For lower level of isolation the distribution is smooth but for isolation > 0.8 and 1 the distribution mainly peaks at two extremes





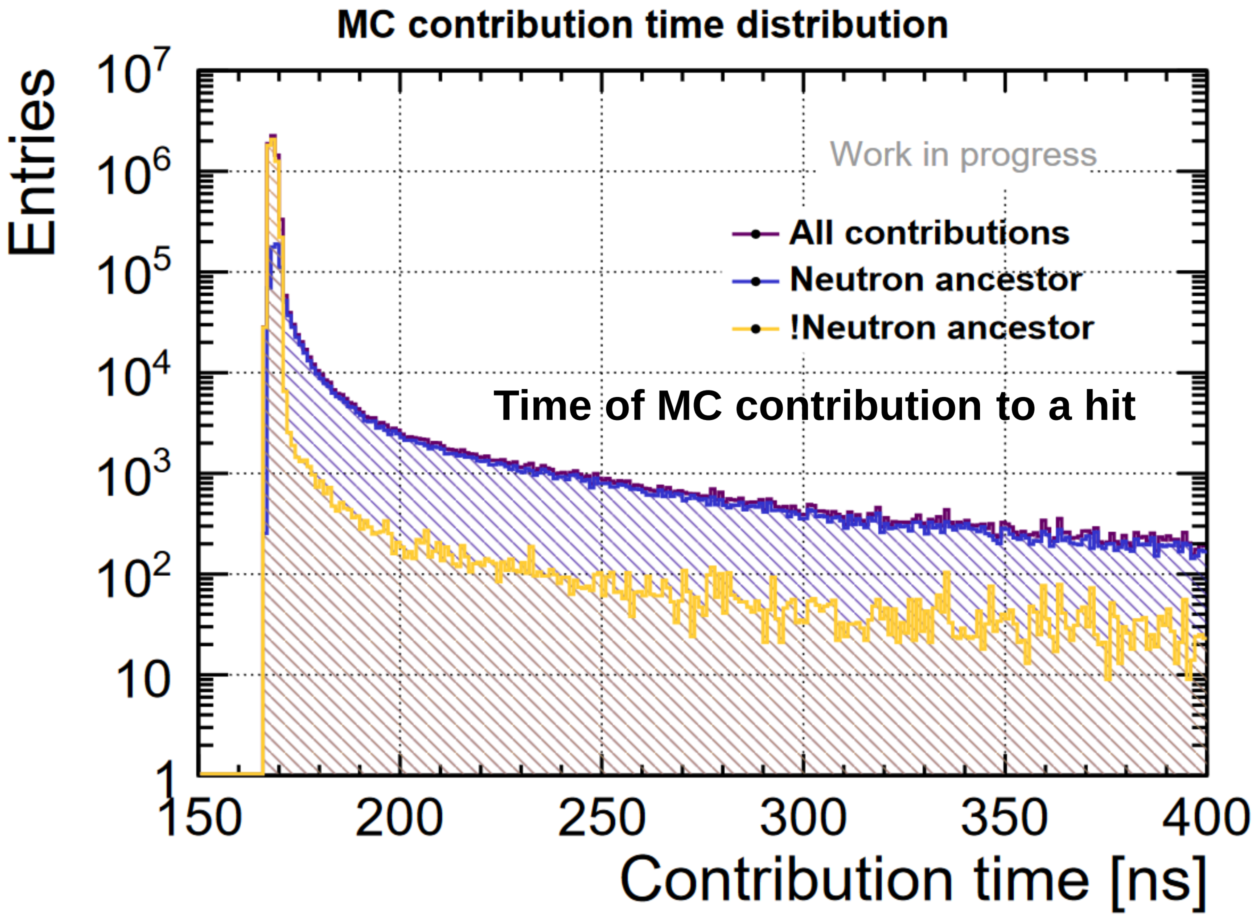
Time stamps

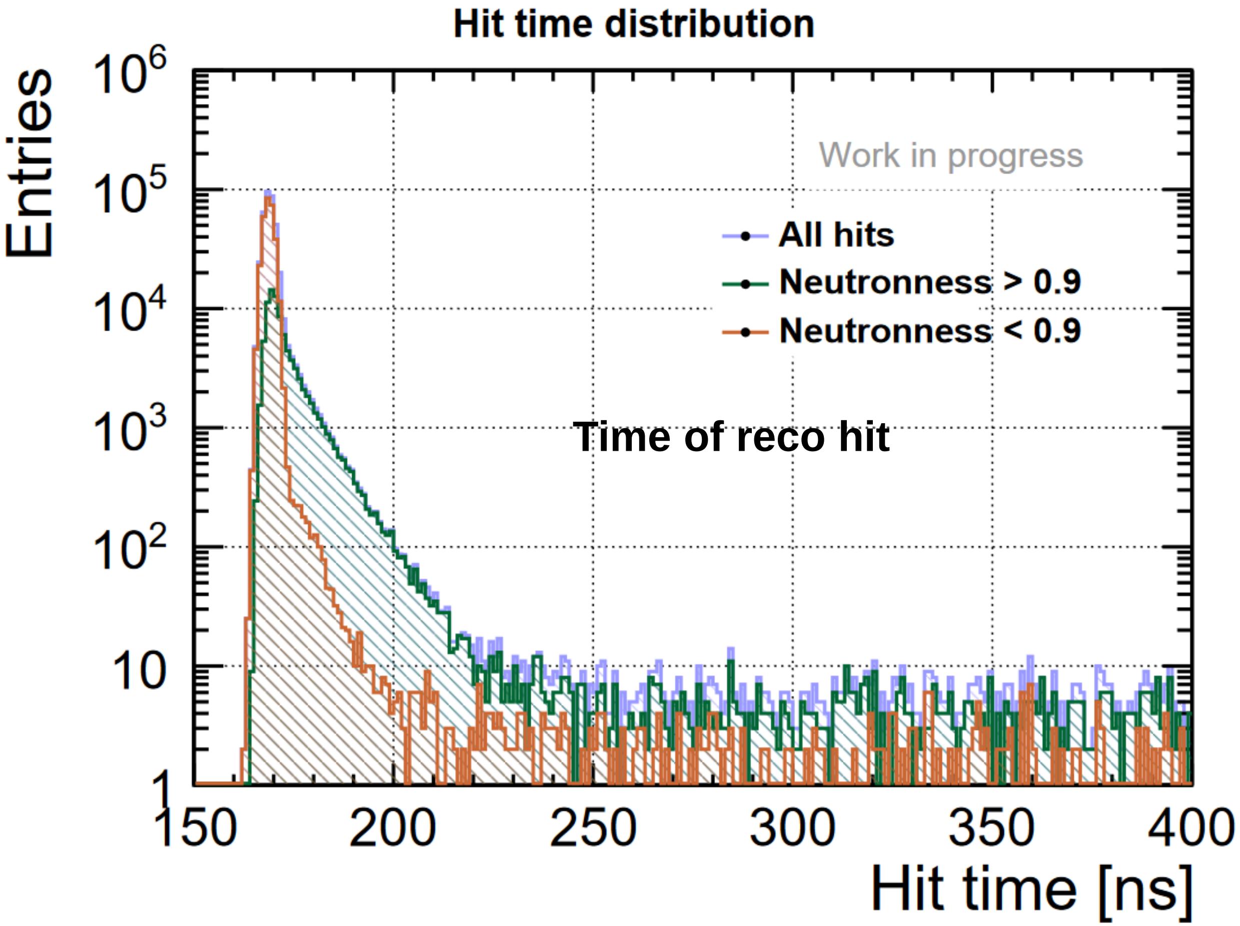
- Correlate neutronness with time stamp – we assume neutrons are late.
- In simulation, the time stamp is given relative to the simulation start, in our case when the pion started its way to the calorimeter.
- Look at **MC time**: exact time stamp of the MC contributions to a SIM hit.
- Look at **RECO time**: time stamp assigned by the standard reconstruction to a reconstructed hit.

Time distribution

ILC Mode: the first ~200 ns after shower start

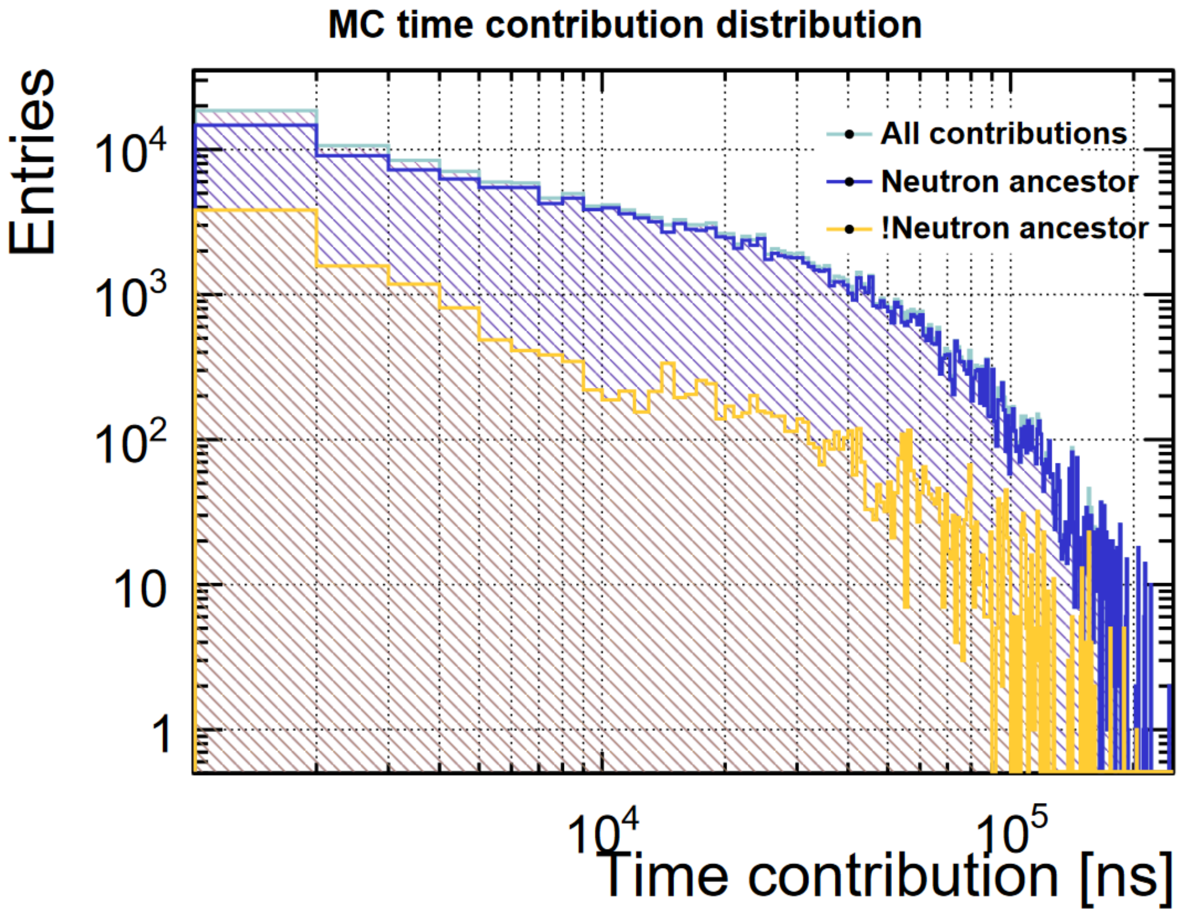
- Vast majority of hits with 15 ns < t < 50 ns after shower start are from neutrons
- Consistent between MC time stamp and hit time stamp

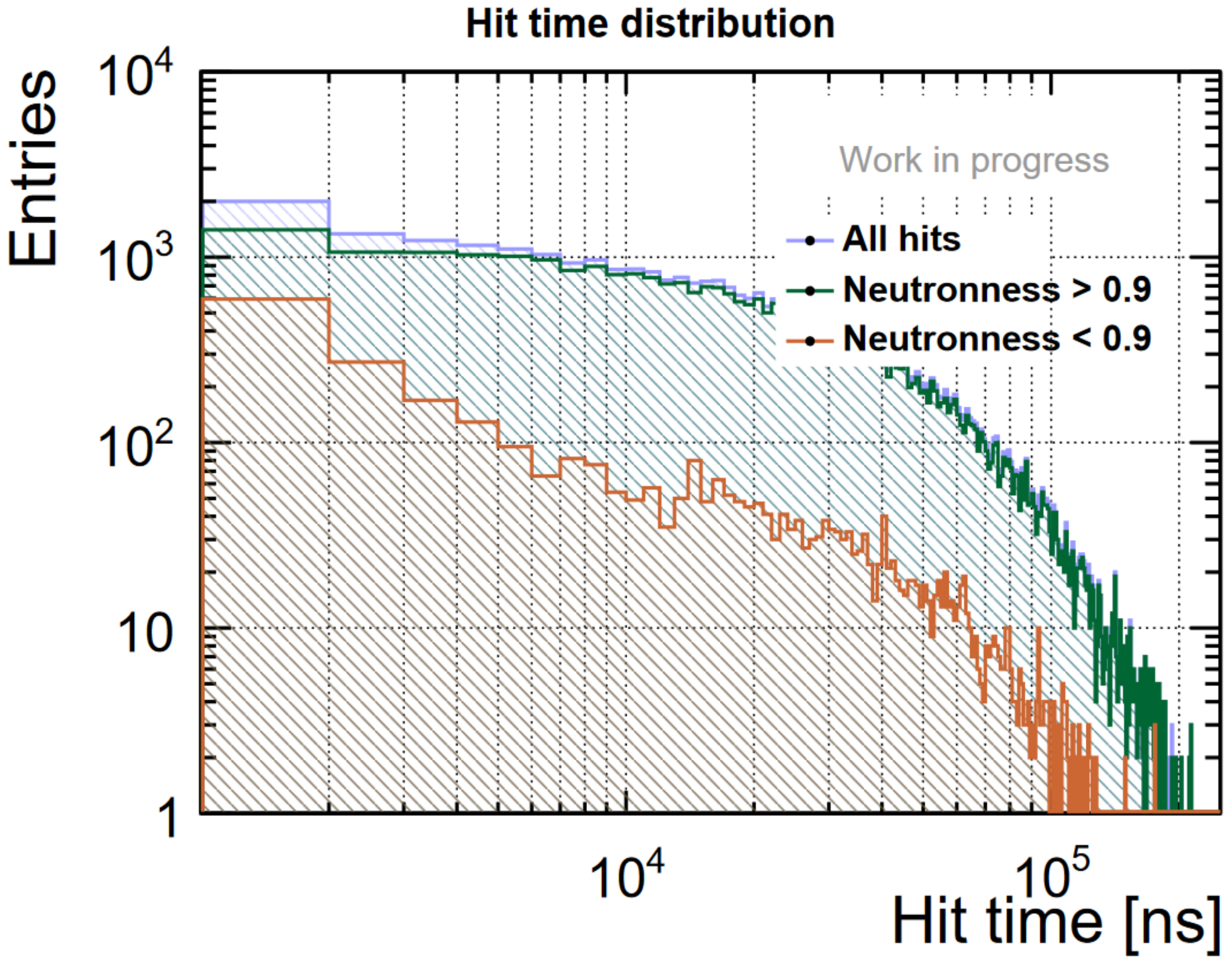




Time distribution

- The long term after-glow comes from neutrons.
- Neutrons are an order of magnitude more than non-neutrons for t > ~5 µs.

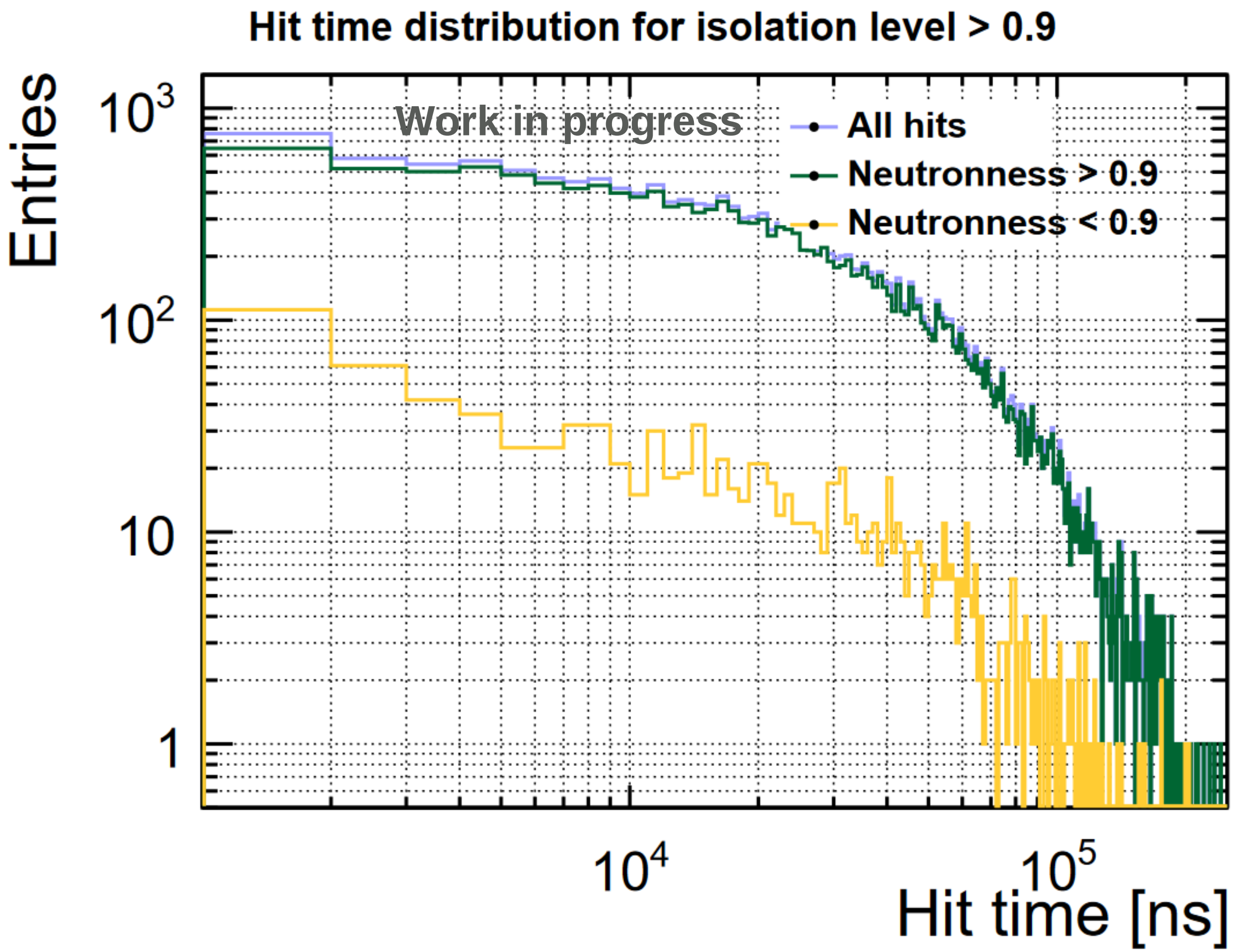


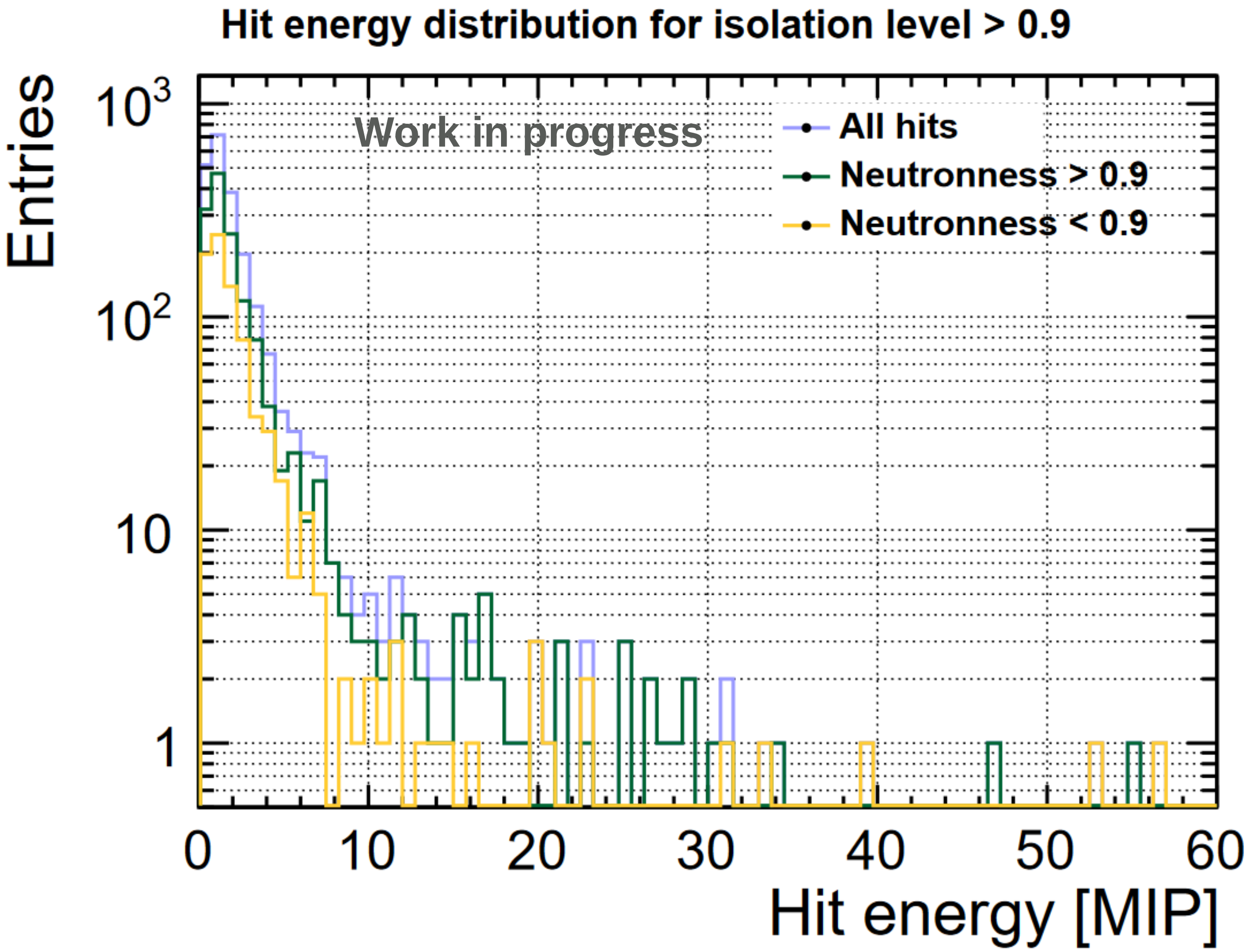


Hit distribution

Isolation level > 0.9

Most of the late hits which are isolated are from a neutron depositing energy of ~ 5 - 10 MIPs





Summary & Outlook

- Implemented as a MARLIN Processor.

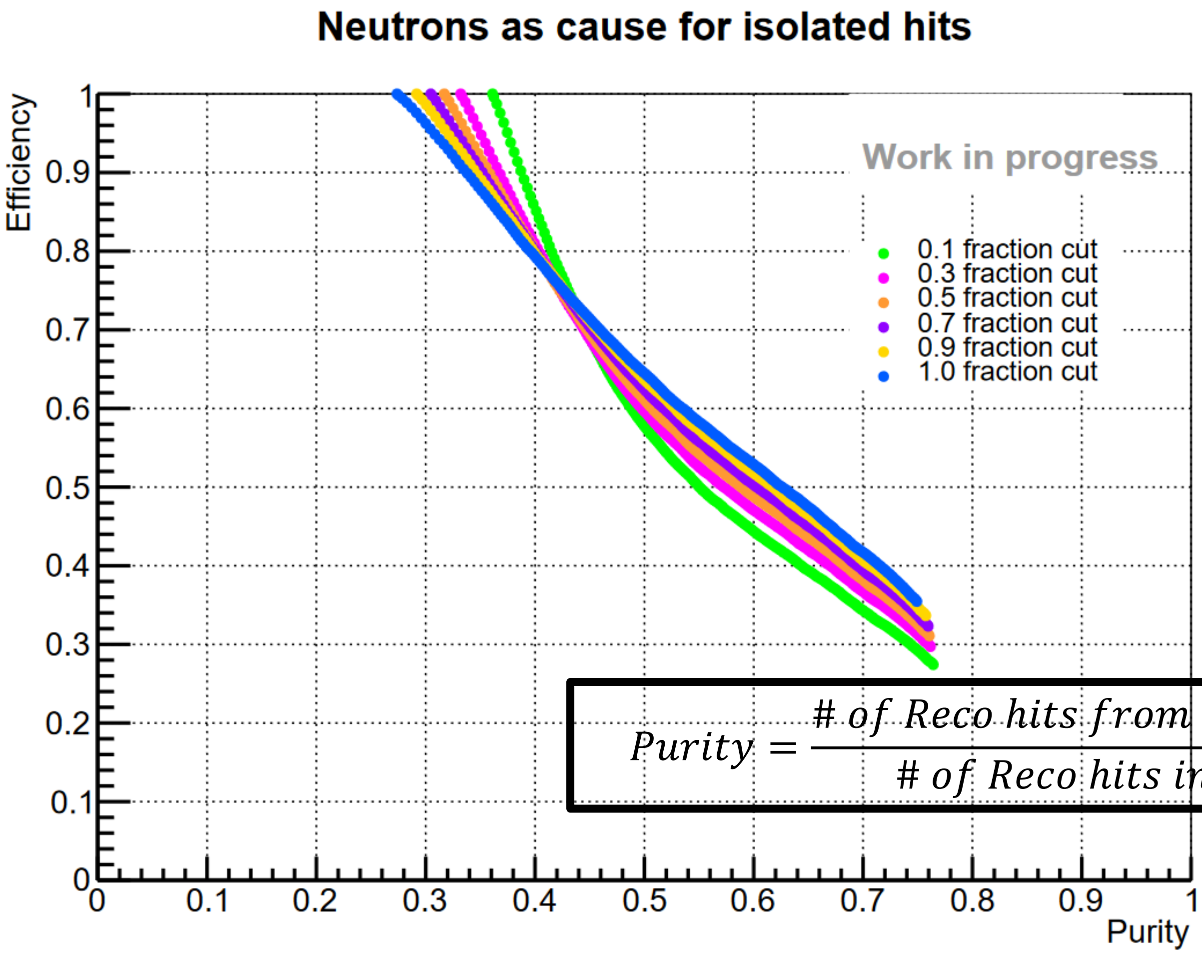
- Most of the isolated late hits are from neutrons → can use isolation observable to separate neutrons.

- Study correlation of neutronness with shower shape variables.

THANK YOU

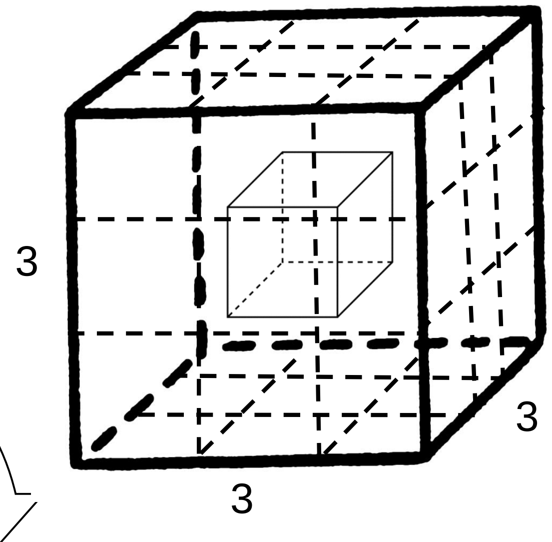
Efficiency Vs. Purity

$$Efficiency = \frac{\#\ of\ Reco\ hits\ from\ a\ neutron\ in\ the\ accepted\ range}{\#\ of\ Reco\ hits\ from\ a\ neutron\ in\ the\ total\ range}$$

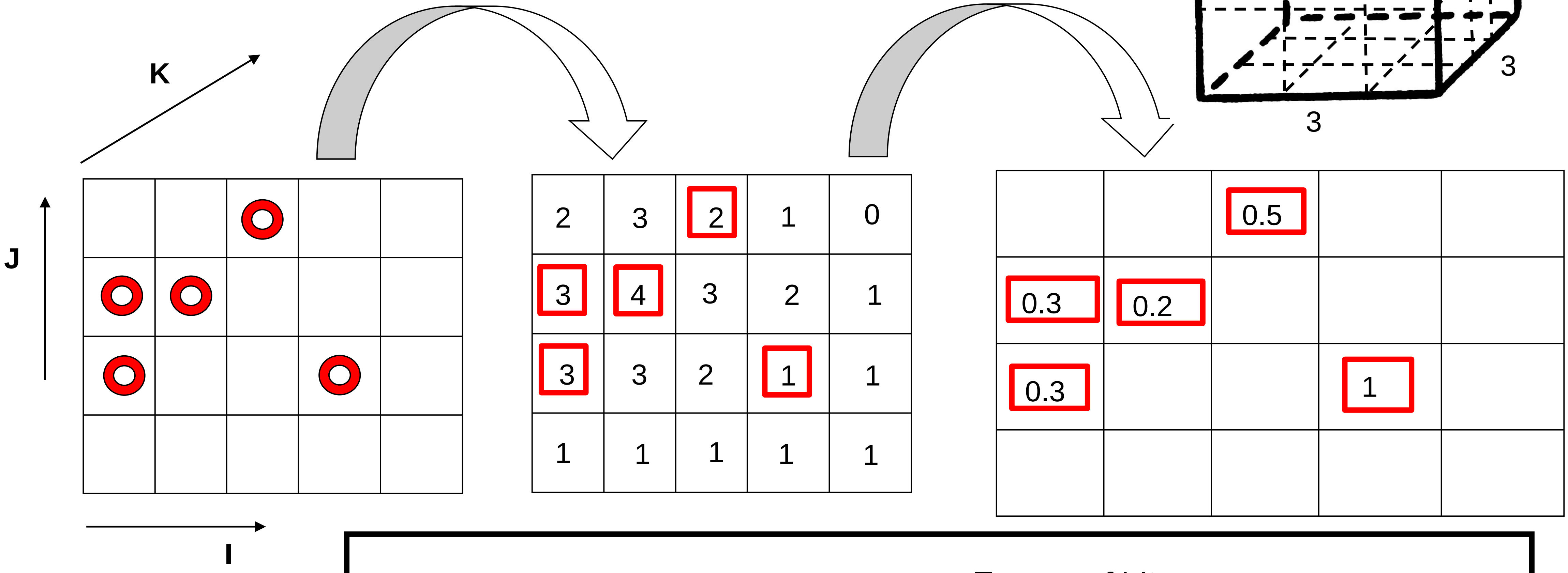


$$Purity = \frac{\#\ of\ Reco\ hits\ from\ a\ neutron\ in\ the\ accepted\ range}{\#\ of\ Reco\ hits\ in\ total\ in\ the\ accepted\ range}$$

Definition of Isolation level



Compares its energy to the energy in its **neighbours**



$$\text{Degree of isolation} = \frac{\text{Energy of hit}}{\text{Energy sum of all neighbours (all hits in } 3 \times 3 \times 3 \text{ box)}}$$

Time distribution