Stony Brook University

Neutron background study

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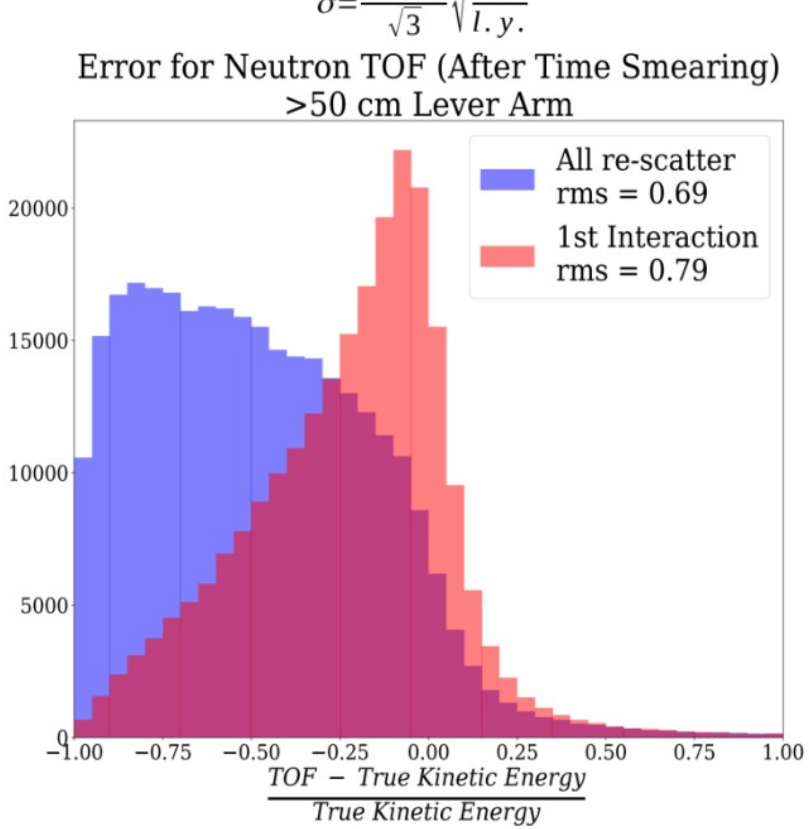
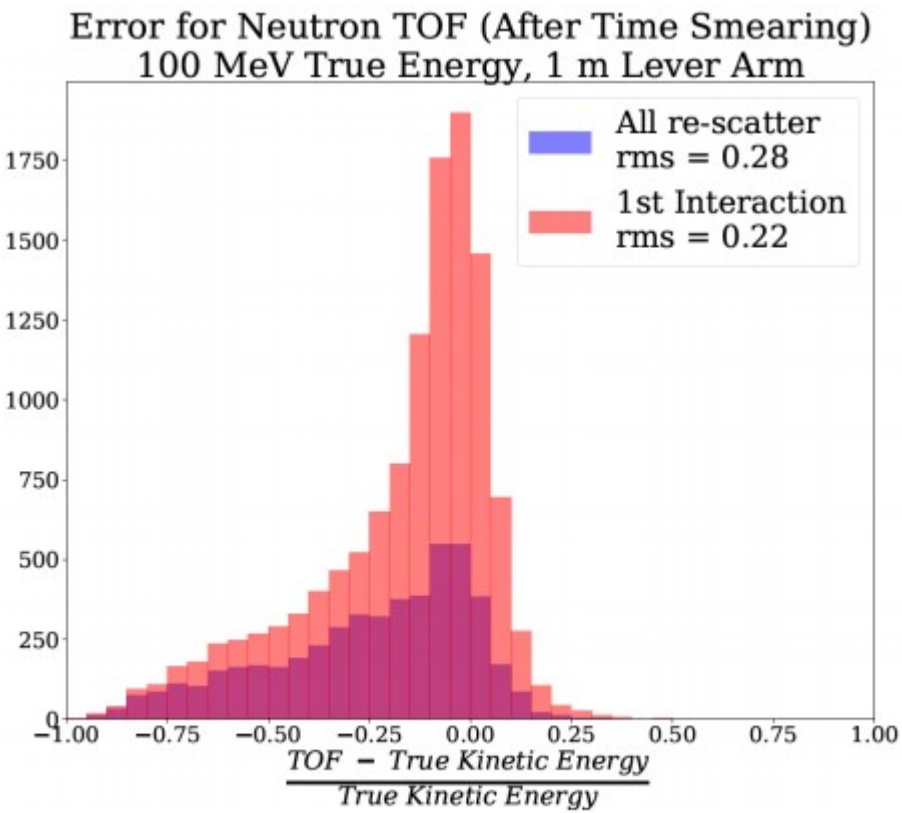
Motivation

- We have >70% efficiency across most of the neutron energy range.
- We will have great (~20% for 100 MeV neutron with ~ 1 m lever arm) energy resolution with ToF.
- A concern is the neutron background hits, which can smear out the signal hits.
- We try to perform a study to understand the neutron background in the 3DST neutron detection.

Neutron energy reconstruction in 3DST

$$\sigma = \frac{0.92\,ns}{\sqrt{3}}\sqrt{\frac{50}{l.y.}}$$



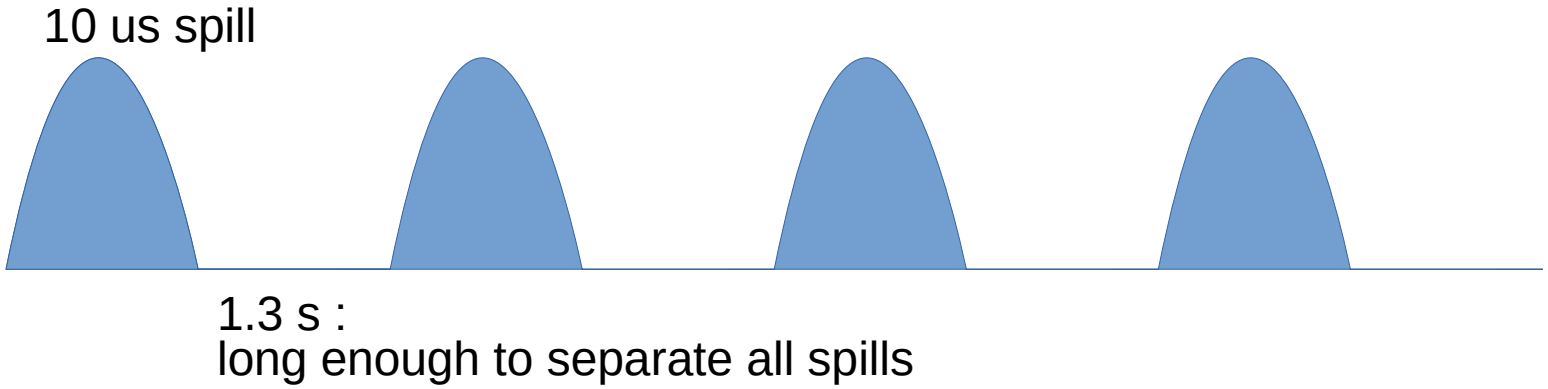


1.5 MeV Threshold

- The energy resolution is sensitive to the lever arm.
- Smeared with 1ns; 1st interaction is the one we care the most.

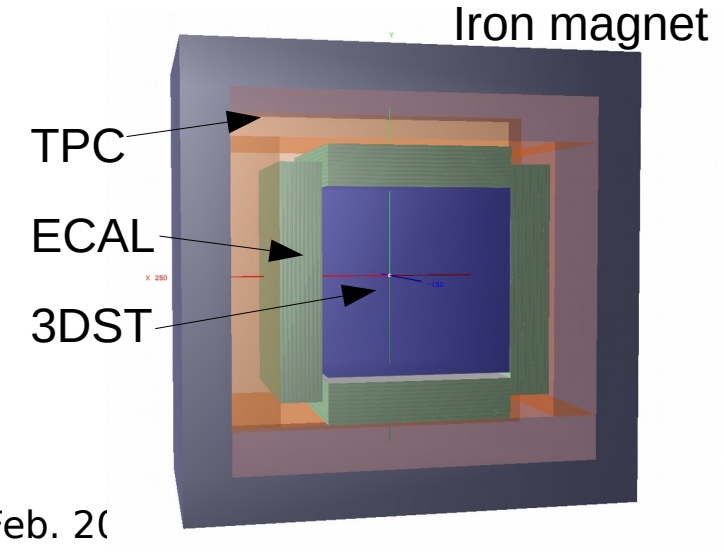
Beam structure

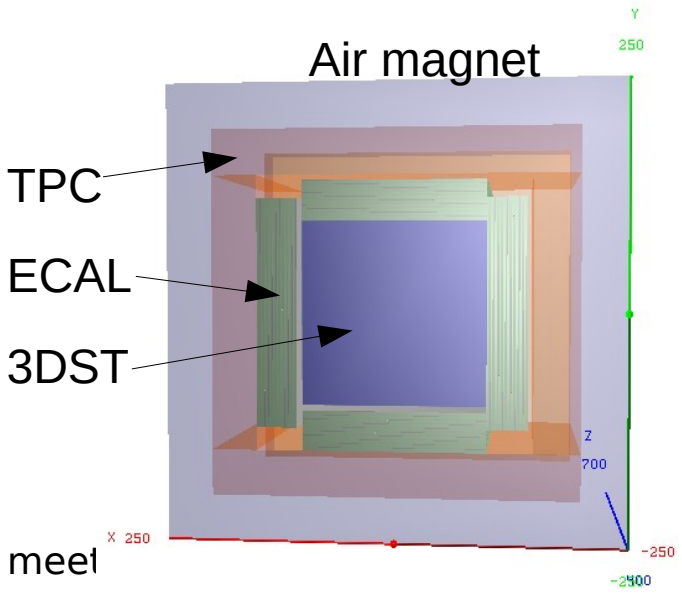
- Each spill separated by 1.3 s.
- Each spill lasts 10 us with 7.5E13 POT.
- We consider each spill separately.



Geometry

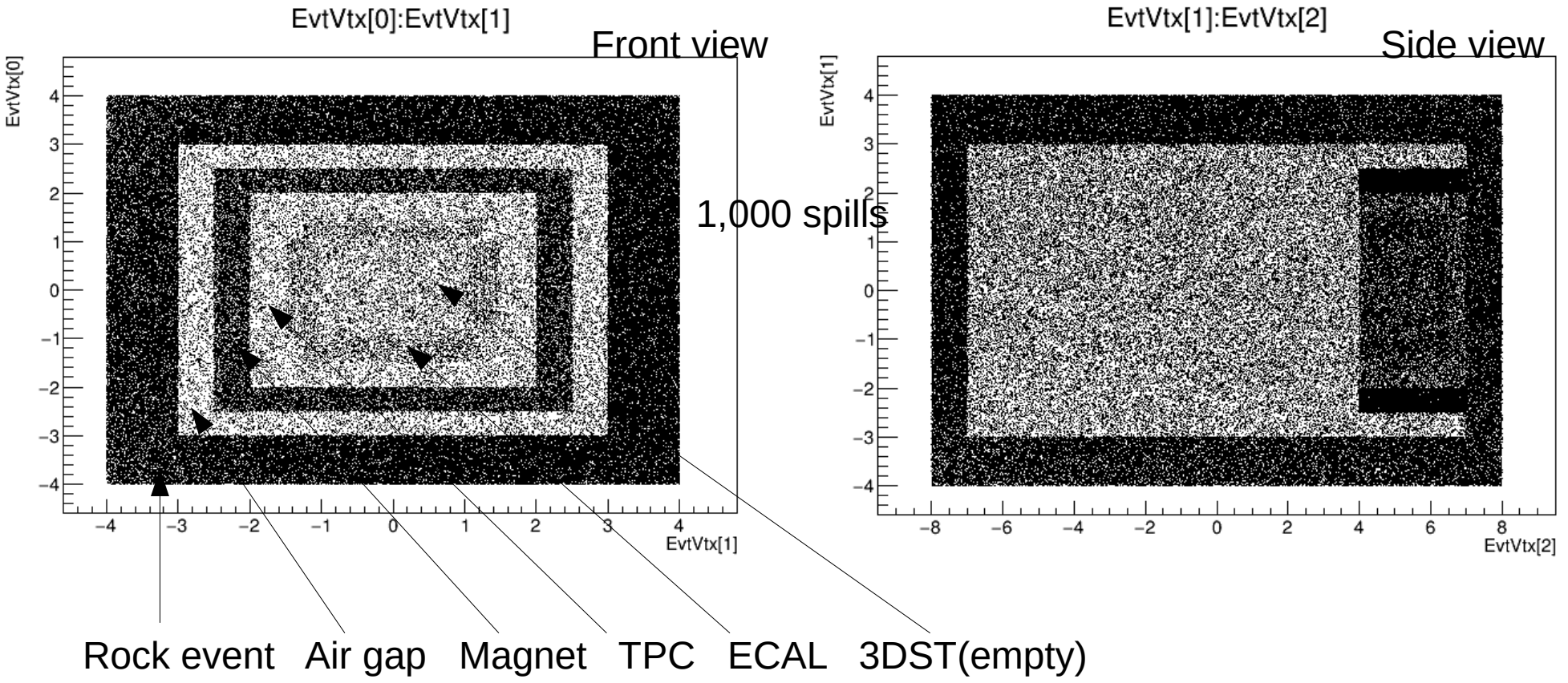
- We try to study the case with magnet and without magnet: 0.5 m iron shell is assumed to be magnet (We are looking at SeaQuest).
- The size of whole 3DST system is assumed to be 3x3x5 m^3 (2x2x2 m^3 3DST). An alcove with extra 0.5 m working space is assumed to surround the 3DST system. Front face rock is far away assuming PRISM moves other detectors.
- We could swap the ECAL and TPC → less acceptance for neutron background from ECAL
- 1 meter rock shell is included
- One spill gives > 200 interactions in this configuration





Interaction in the geometry

- Neutrino interactions on the XY and YZ views
- Rate proportional to material density



Signal and Background selection

- Events: vertex in the 1x1x1 m^3 core of 3DST
- Record the vertex time and search for the earliest hit caused by neutron scattering that > 1.5 MeV with a lever arm > 40 cm, or > 80 cm.

  - if that hit is from the vertex interaction, it is a signal

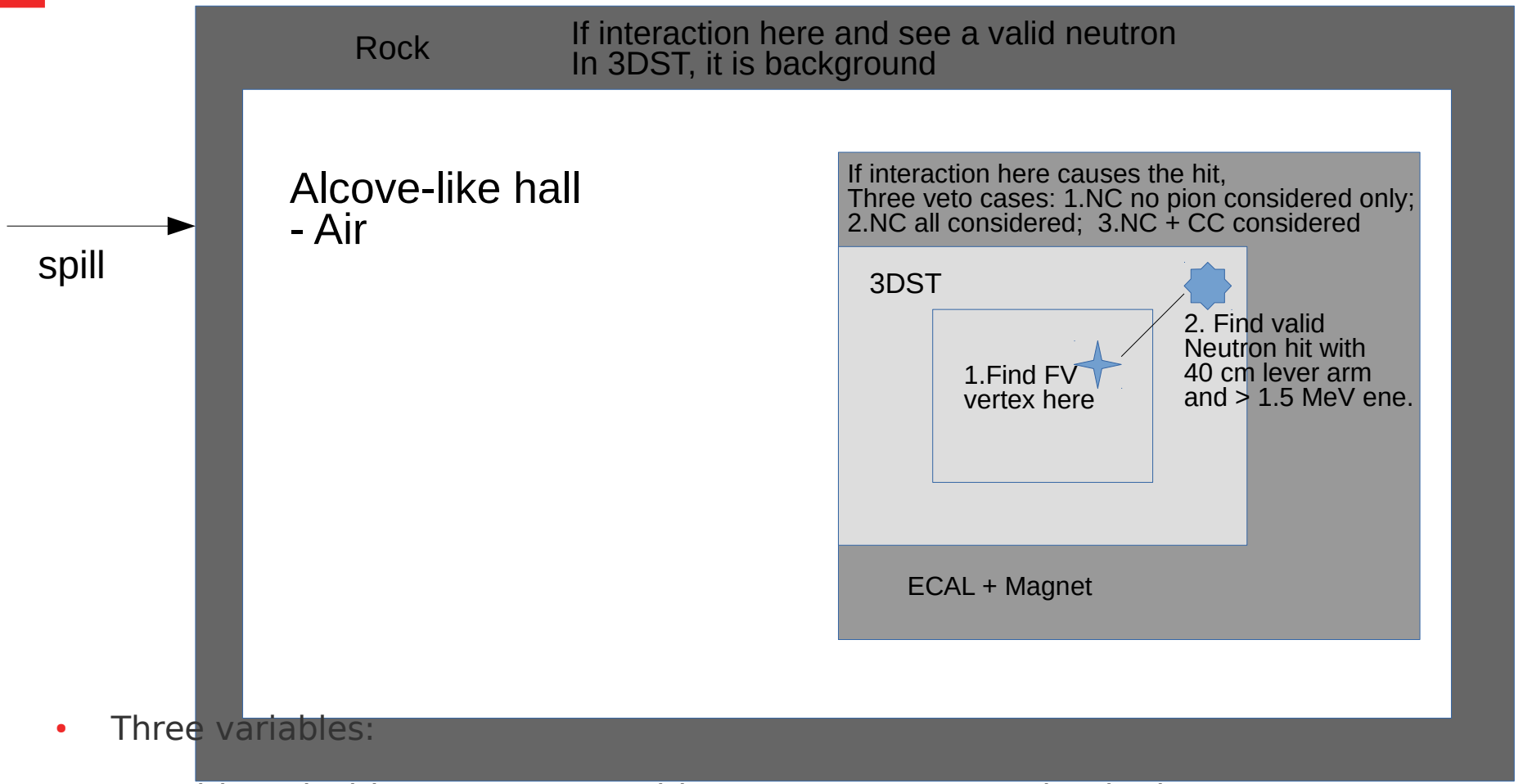
  - if that hit is from the region outside 3DST, it could be a background hit:

    a). If the interaction happens in the rock, it is a background

    b). If the interaction happens in the ECAL or Magnet, three cases (Background veto):

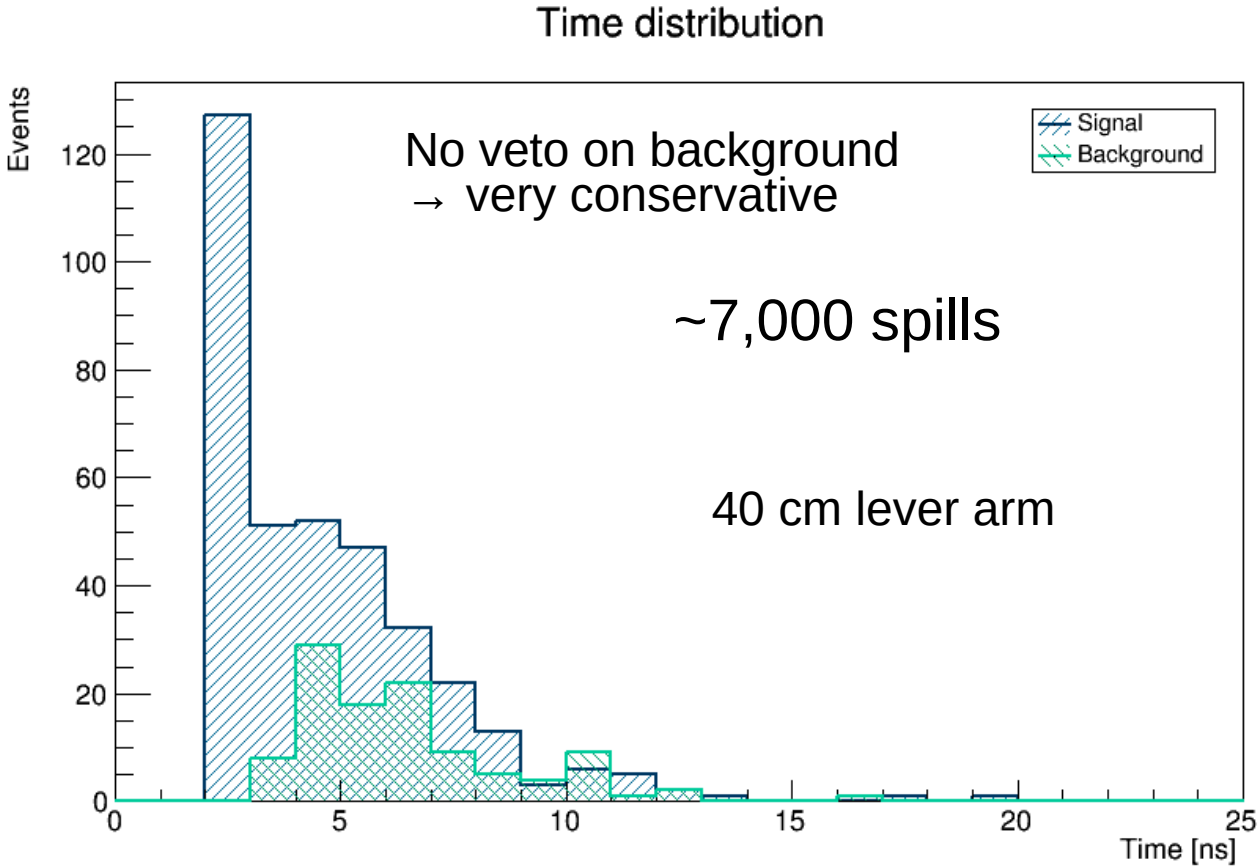
    1. It must be a NC without pion > 50 MeV
    2. It must be any NC
    3. It could be NC or CC, everything.

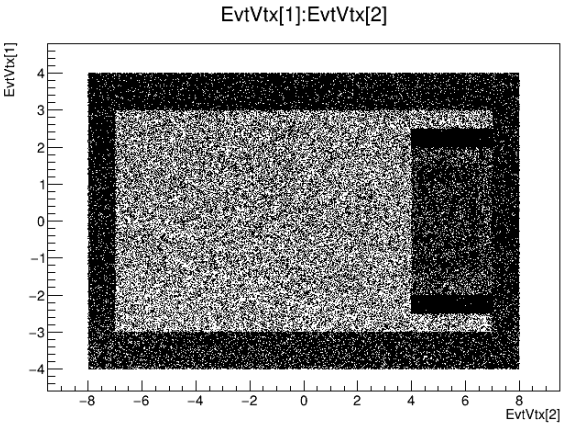
Signal and Background selection



- Three variables:
  - With and without magnet → without magnet expected to be better
  - Neutron-induced hit energy deposit coming after vertex → no big difference
  - ECAL+Magnet background veto → important

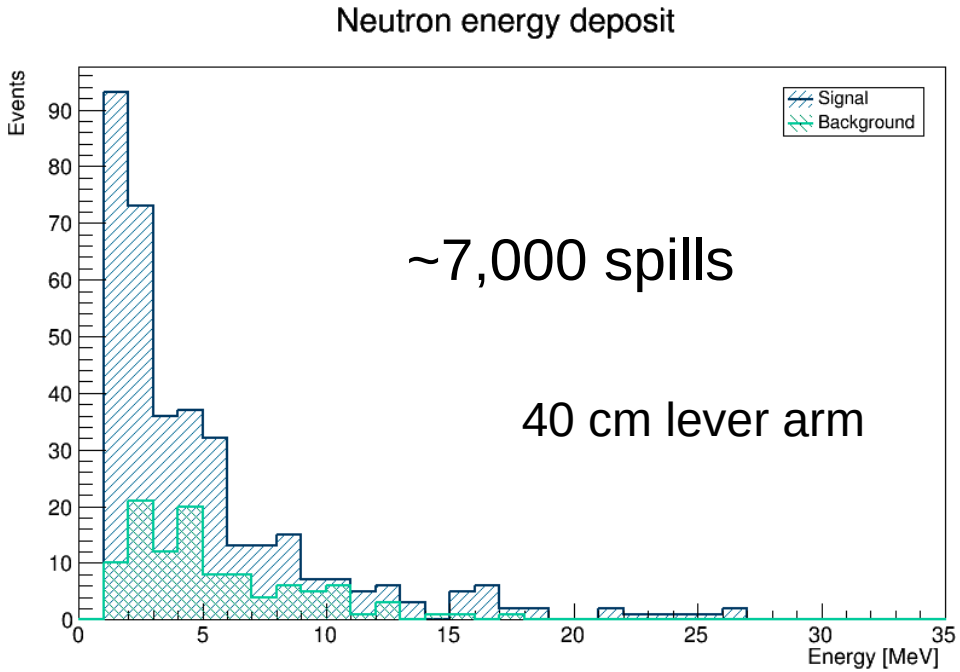
Distribution hit time – vtx time

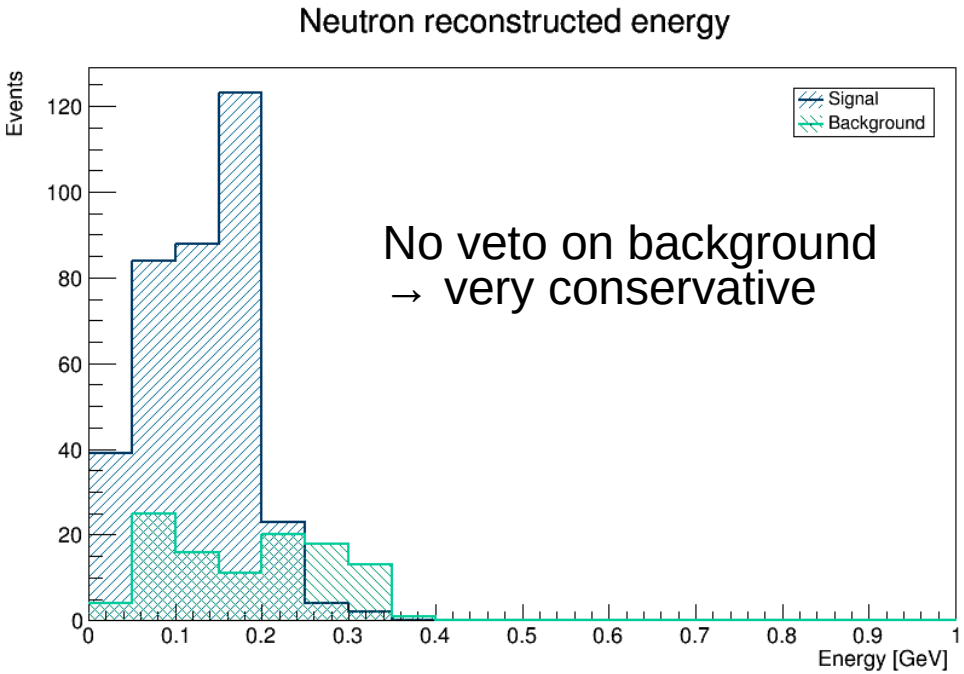




- With iron magnet + 1.5 MeV deposit threshold + all NC+CC in ECAL/Magnet/Rock considered as background
- Time is not very large to allow outside background hits coming in.

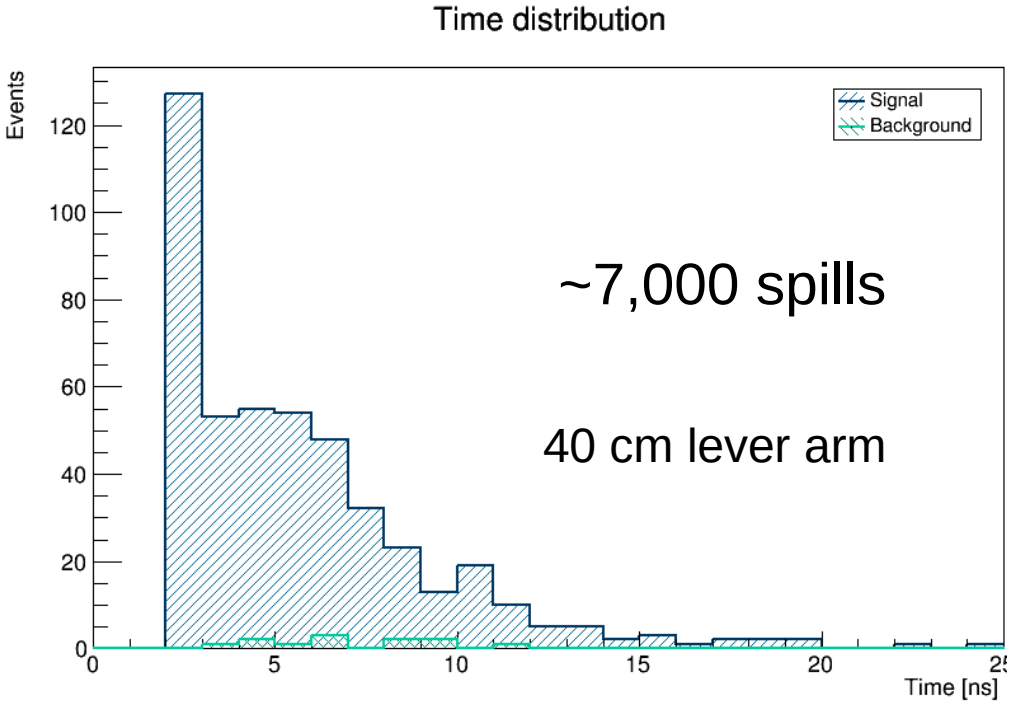
Signal vs. background

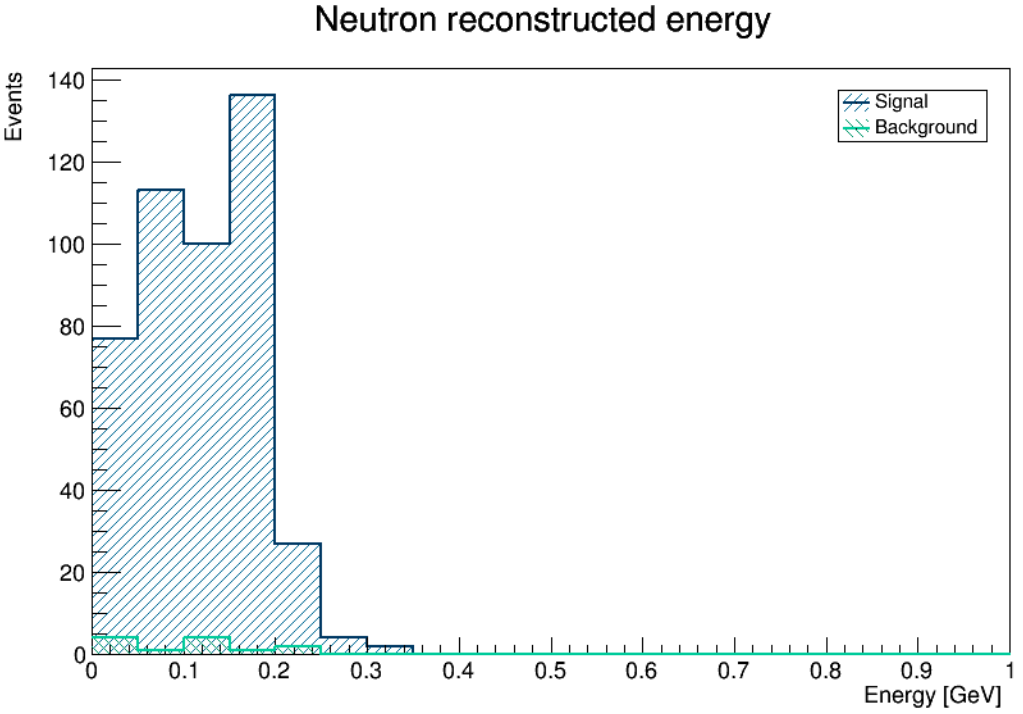




- With iron magnet + 1.5 MeV deposit threshold + All CC+NC in ECAL/Magnet/Rock considered as background
- Most of the background coming from ECAL/Magnet, almost none from Rock

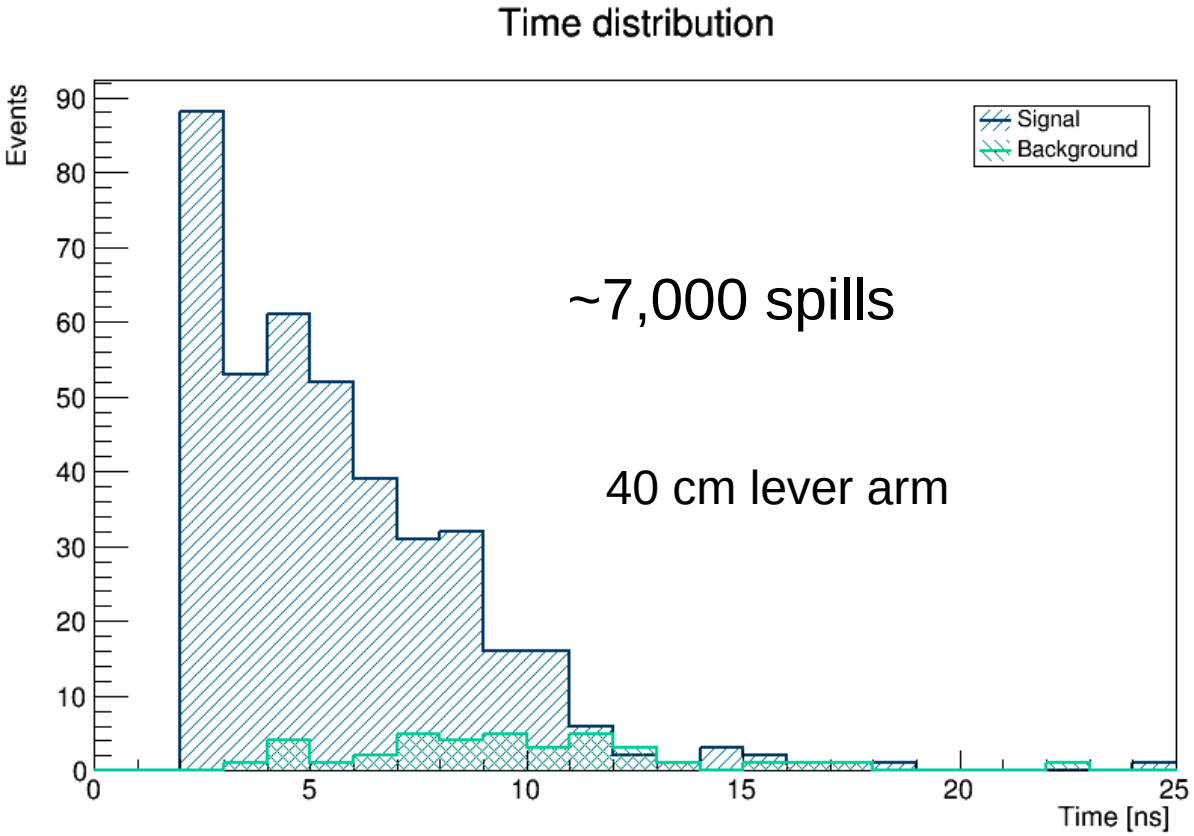
Signal vs. background

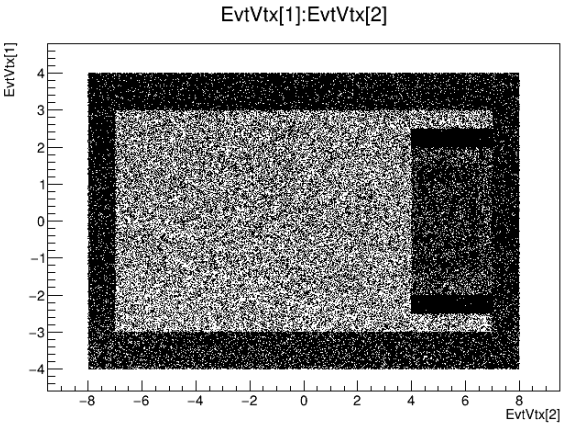




- With iron magnet + 1.5 MeV deposit threshold + NC without pion in ECAL/Magnet/Rock considered as background
- Most of the background coming from ECAL/Magnet, almost none from Rock

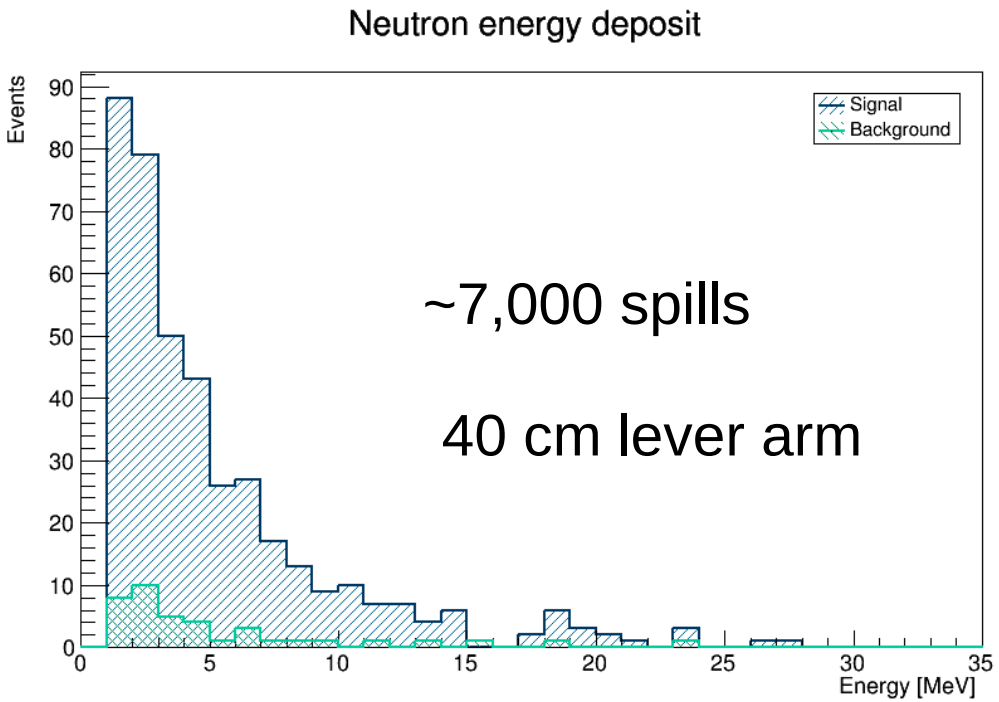
Distribution hit time – vtx time

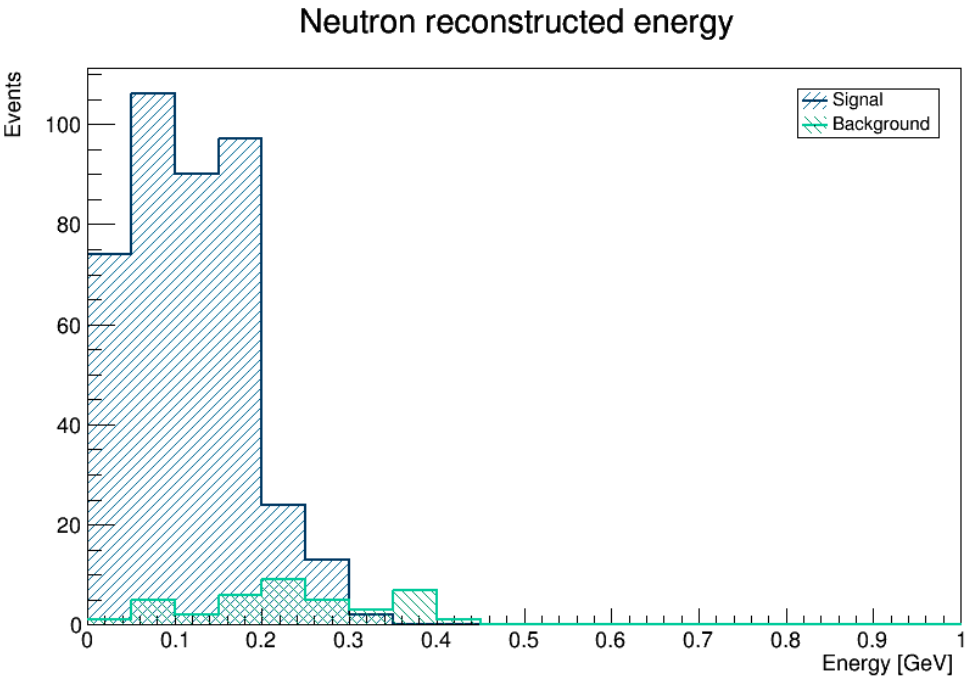




- Without magnet + 1.5 MeV deposit threshold + all NC+CC in ECAL/Rock considered as background
- Background neutrons from Rock can hardly have a comparable travel time to those from 3DST

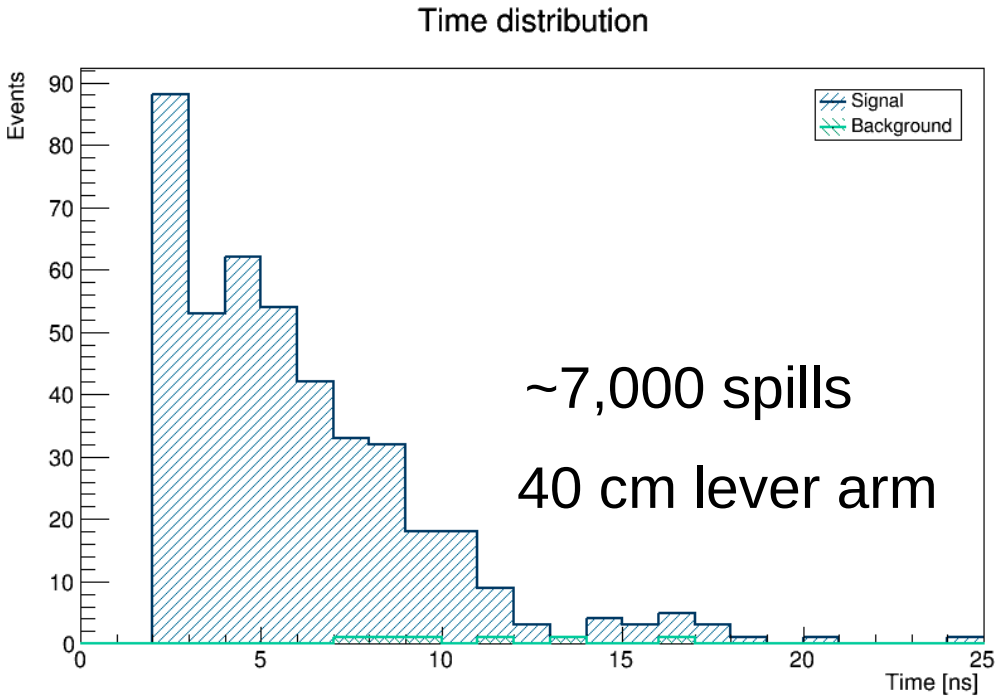
Signal vs. background

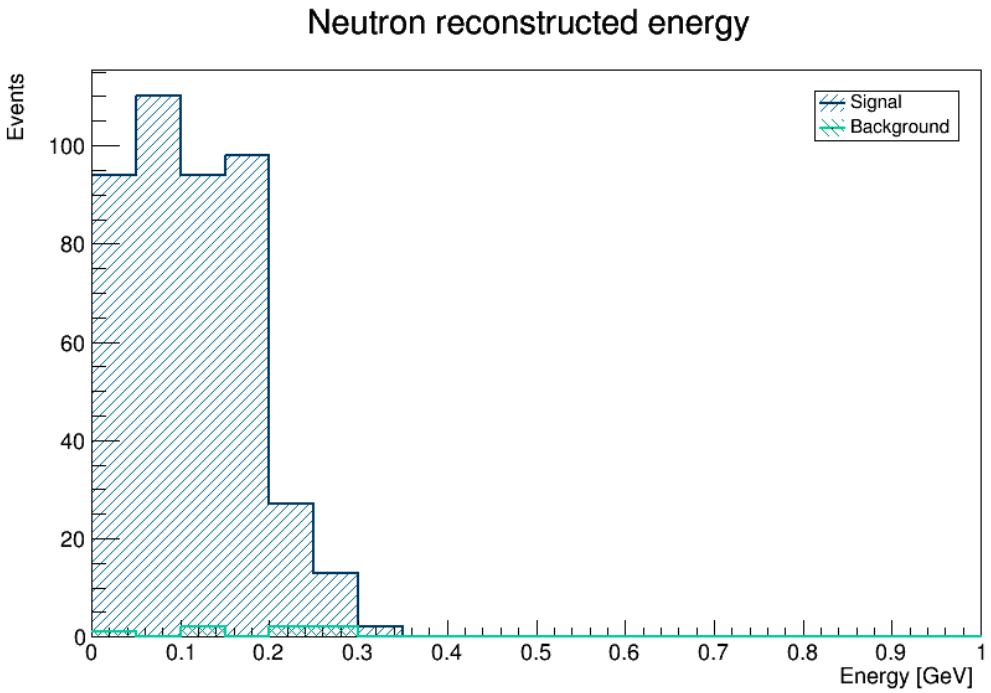




- Without iron magnet + 1.5 MeV deposit threshold + All CC+NC in ECAL/Rock considered as background
- Most of the background coming from ECAL

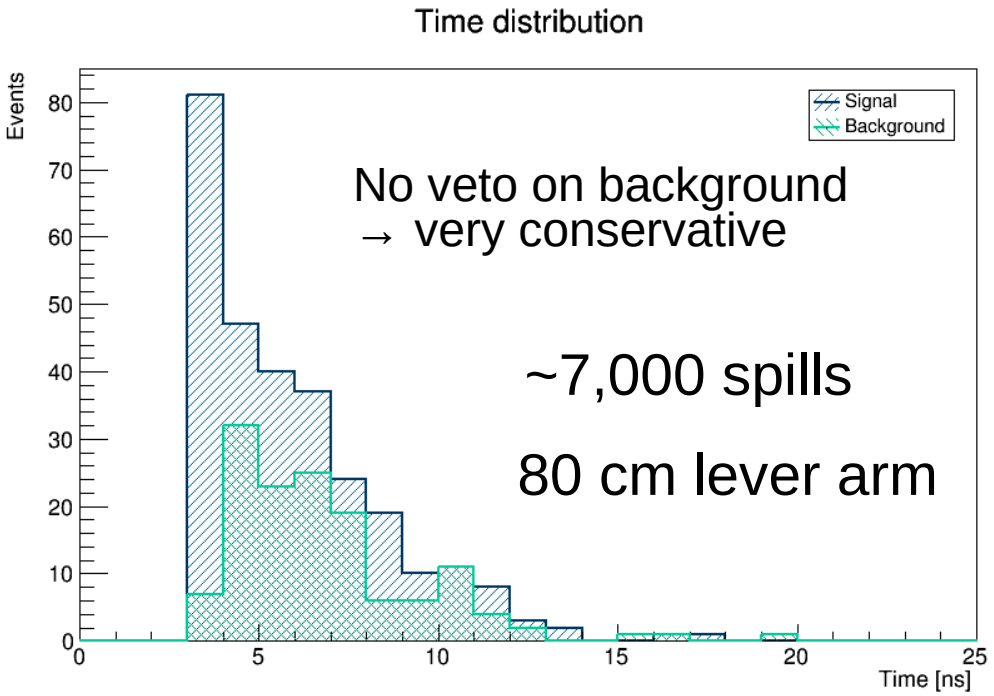
Signal vs. background

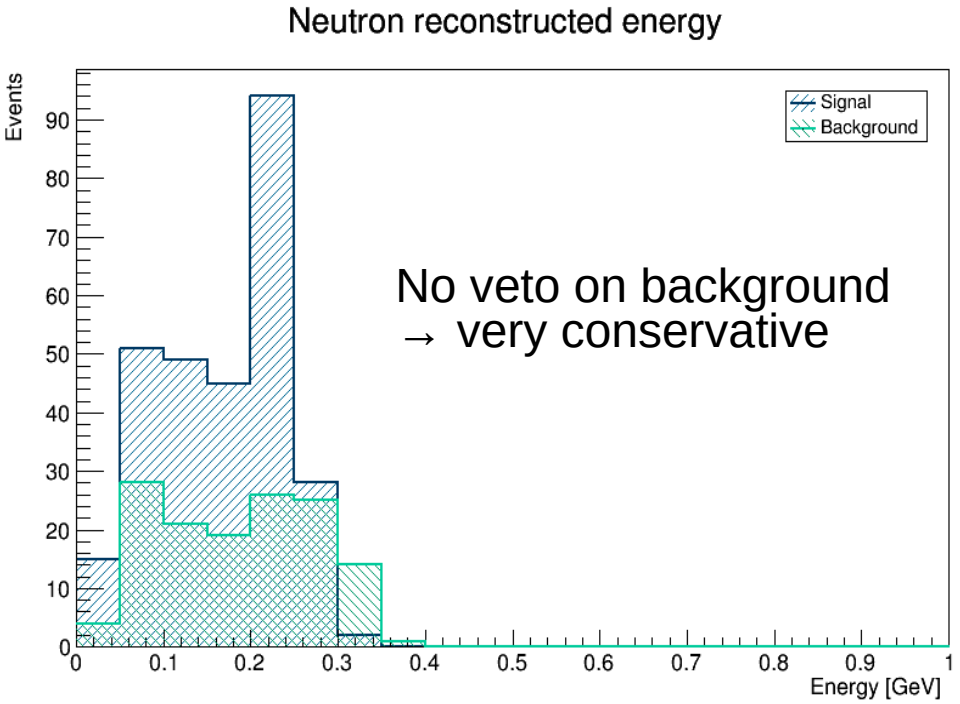




- Without iron magnet + 1.5 MeV deposit threshold + NC without pion in ECAL/Rock considered as background
- Most of the background coming from ECAL

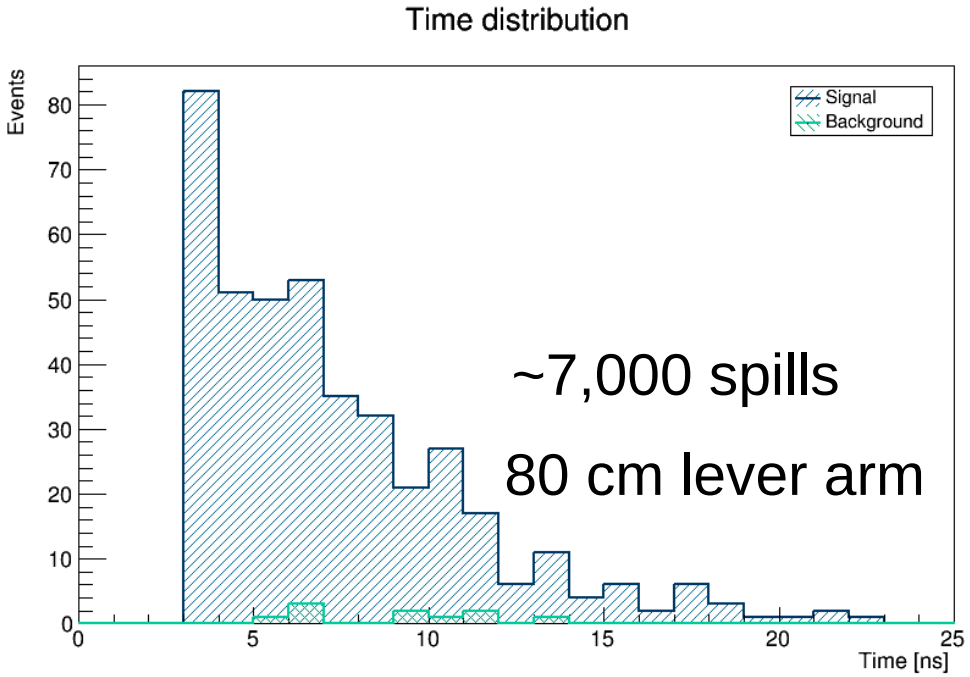
Increasing lever arm

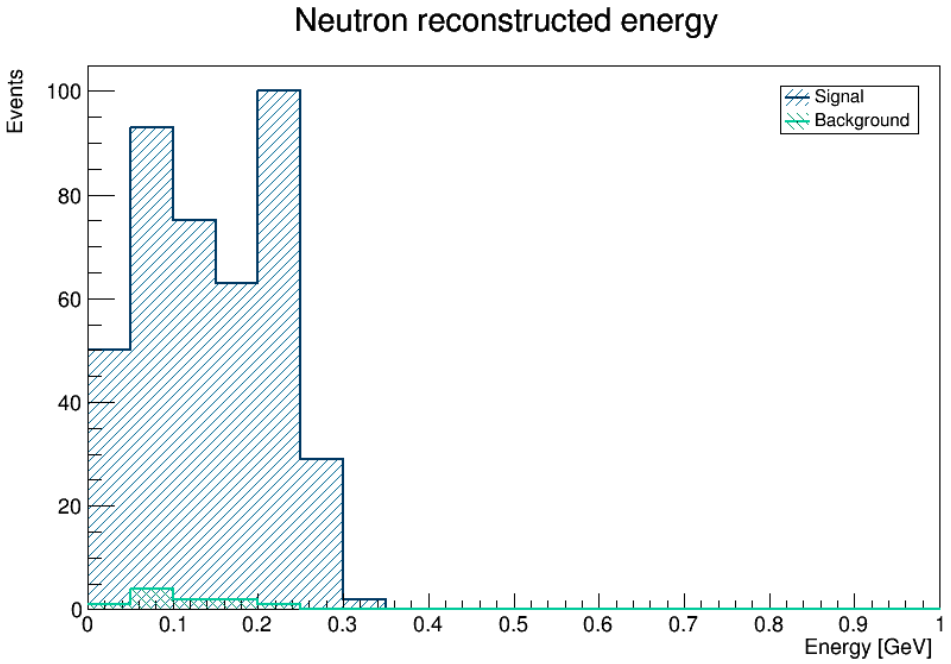




- With iron magnet + 1.5 MeV deposit threshold + All CC+NC in ECAL/Magnet/Rock considered as background
- Allow more event coming in

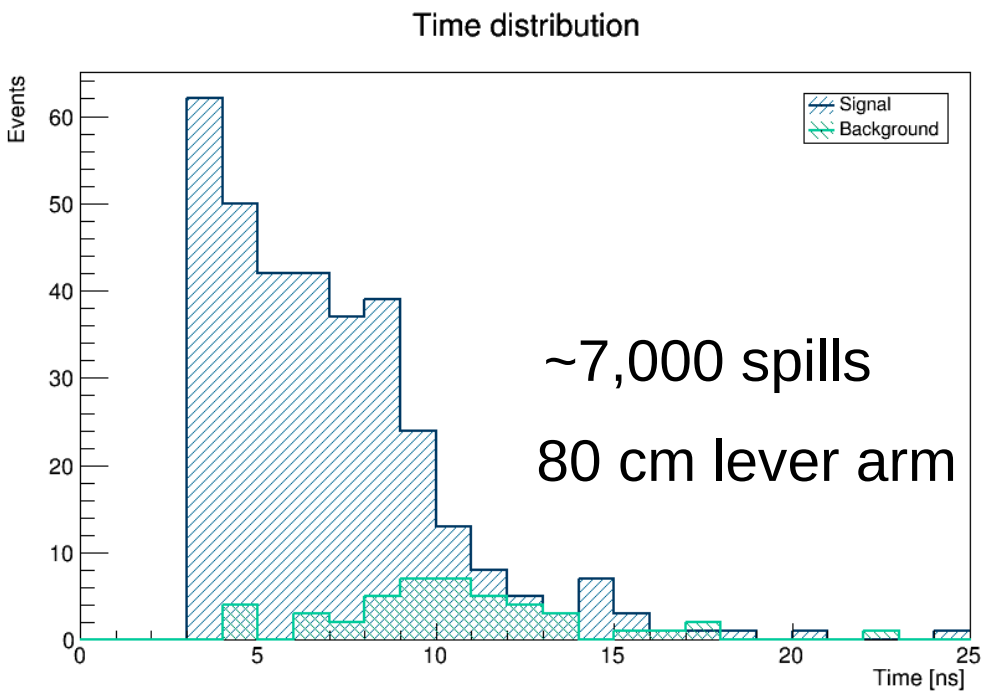
Increasing lever arm

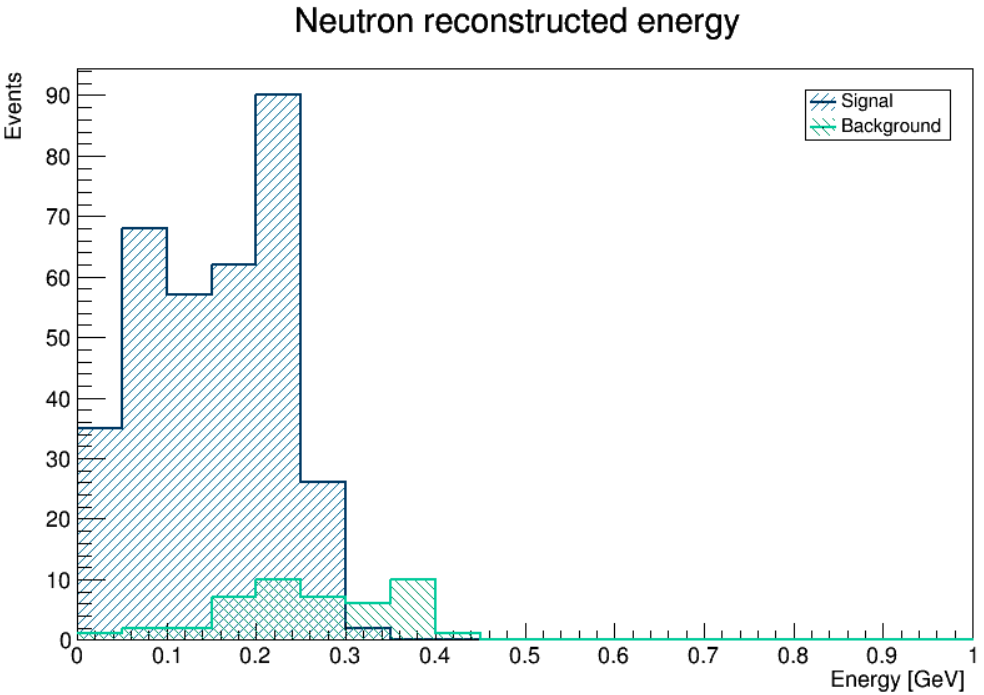




- With iron magnet + 1.5 MeV deposit threshold + NC without pion in ECAL/Magnet/Rock considered as background
- Allow more event coming in

Increasing lever arm





- Without iron magnet + 1.5 MeV deposit threshold + All CC+NC in ECAL/Rock considered as background
- Most of the background coming from ECAL

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Very preliminary conclusion

- We’ve started a neutron background study for the 3DST system.
- There are very few backgrounds from rock, most of them are from ECAL/Magnet.
- With shorter lever arm, we can detect clean neutron signals.
- If loosen the lever arm, we will try a good control of the CC and NC (w/ pion) events outside 3DST cubes.
- We will try to optimize the geometry and cuts such as lever arm.