



3DST Neutron background Update

Manoa Andriamirado (University of Antananarivo)
Guang Yang (Stony Brook)



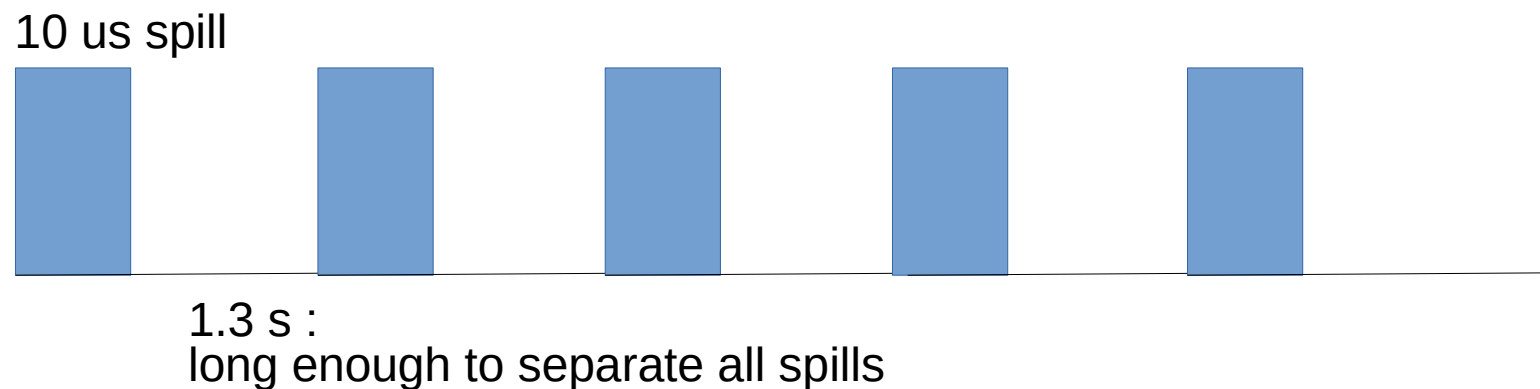
Motivation

- We have $>70\%$ efficiency across most of the neutron energy range.
- We will have good ($\sim 20\%$ for 100 MeV neutron with ~ 1 m lever arm) energy resolution with ToF.
- A concern from DUNE CM is the neutron background.
- We started to study the neutron background in 3DST and preliminary result supported that we are able to handle the background reasonably well.



Beam structure

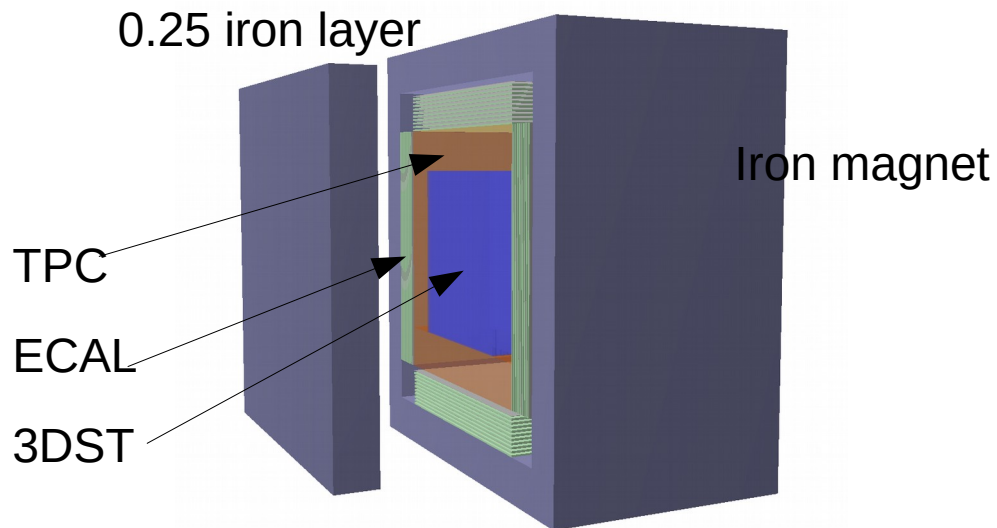
- Each spill separated by 1.3 s.
- Each spill lasts 10 μ s with $7.5E13$ POT.
- We consider each spill separately.



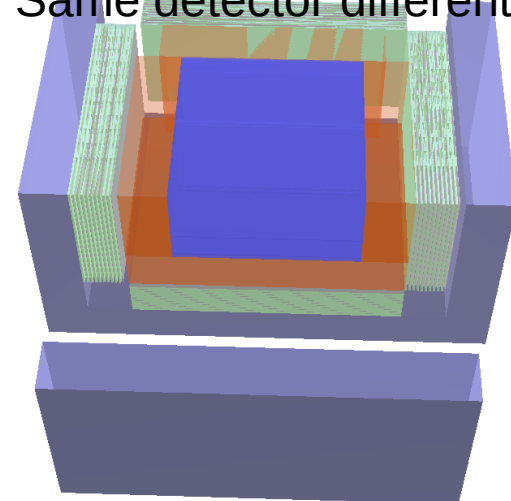


Geometry

- Order inner to outer: $2 \times 2 \times 2 \text{ m}^3$ 3DST \rightarrow 0.5 m shell TPC \rightarrow 0.5 m ECAL \rightarrow 0.5 m magnet
- A $2 \times 2 \times 0.25 \text{ m}$ iron layer in front
- The size of whole 3DST system is $3 \times 3 \times 5 \text{ m}^3$. An alcove with extra 0.5 m working space is assumed to surround the 3DST system.
- 1.5 meter rock shell is included



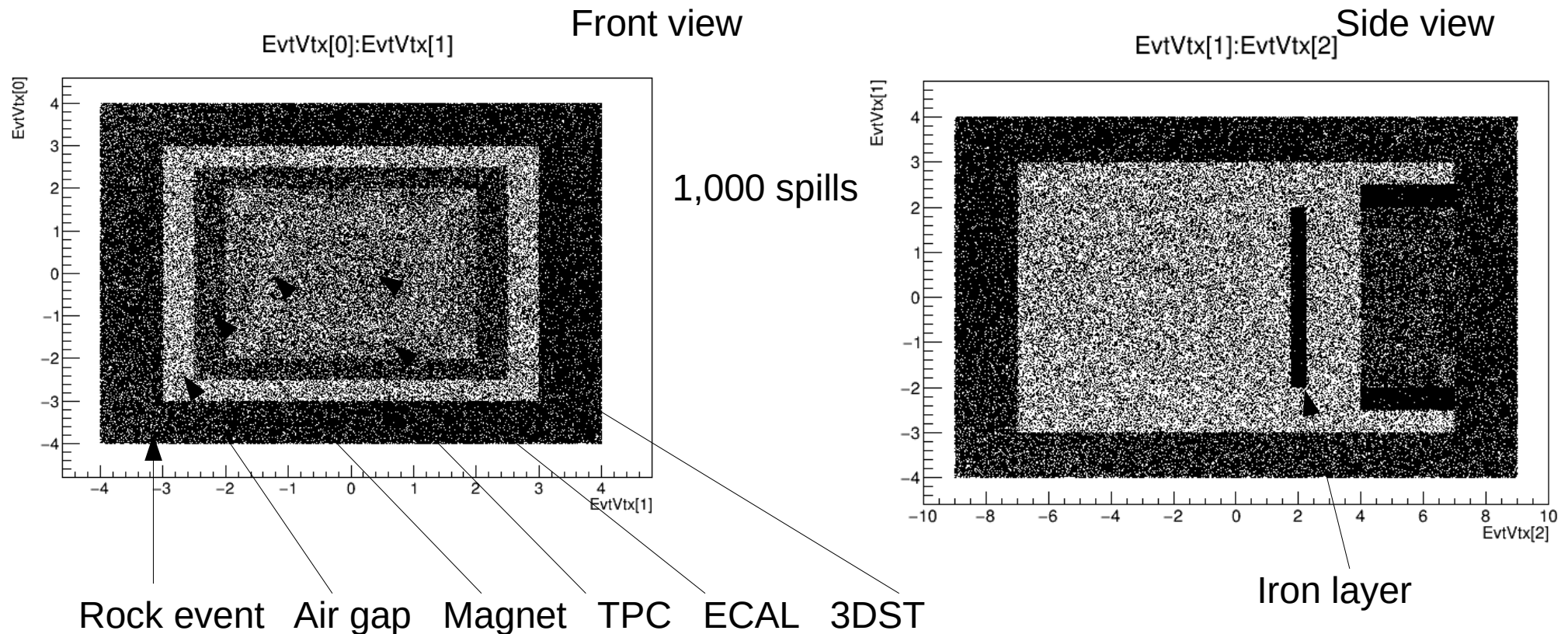
Same detector different view





Interaction in the geometry

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



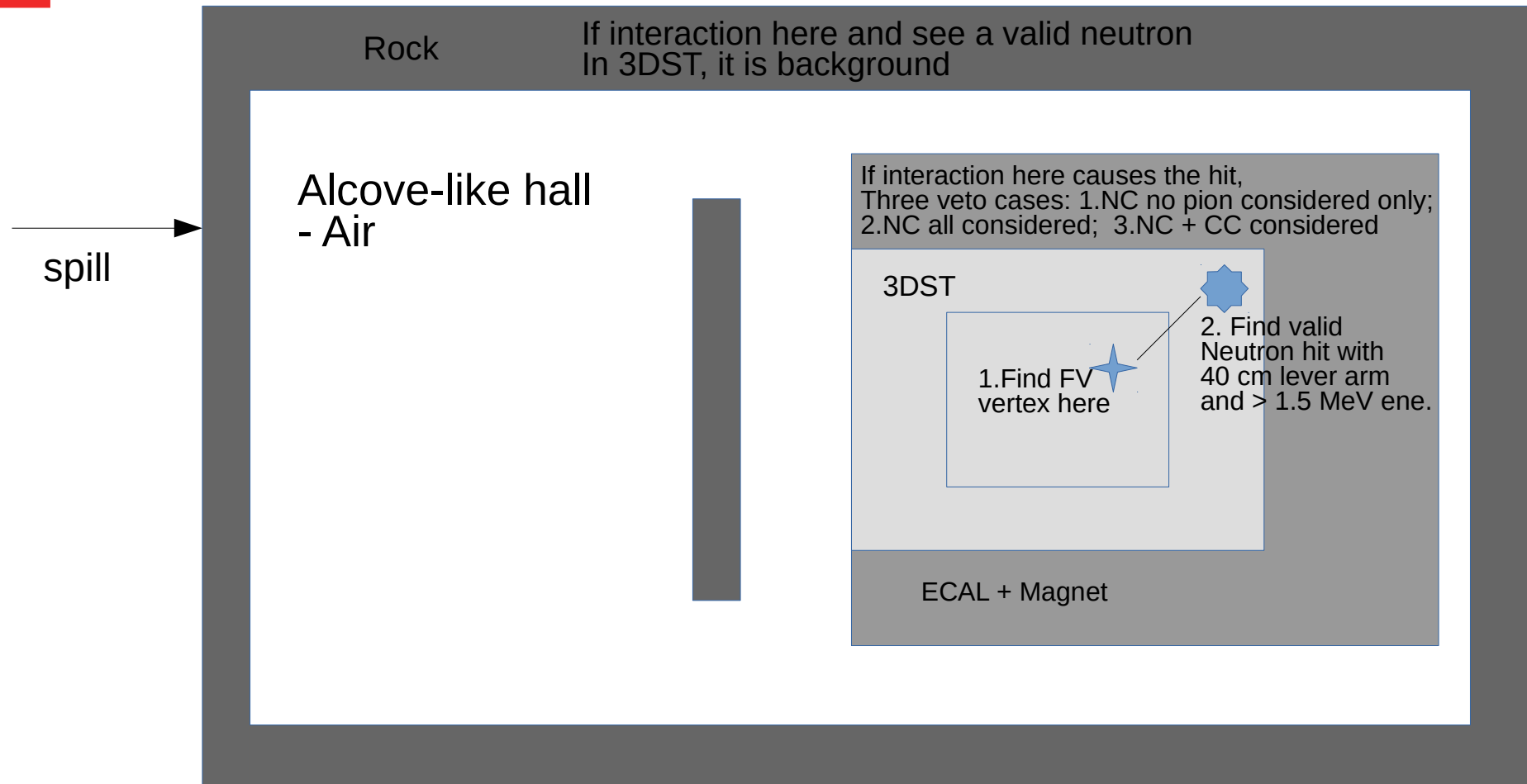


Signal and Background selection

- Events: vertex in the $1 \times 1 \times 1 \text{ m}^3$ core of 3DST
- Record the vertex time and search for the earliest hit caused by neutron scattering that $> 1.5 \text{ MeV}$ with a lever arm $> 40 \text{ cm}$.
- All neutron-induced visible hits are included, i.e. proton, pion, gamma..
 - if that hit is from the vertex interaction, it is a signal.
 - if that hit is from the vertex that outside 3DST, it is a background.
 - We actually have ability to veto the background hits caused by neutrino interactions in ECAL, Magnet, even the front detector.
 - Current way is conservative..



Signal and Background selection

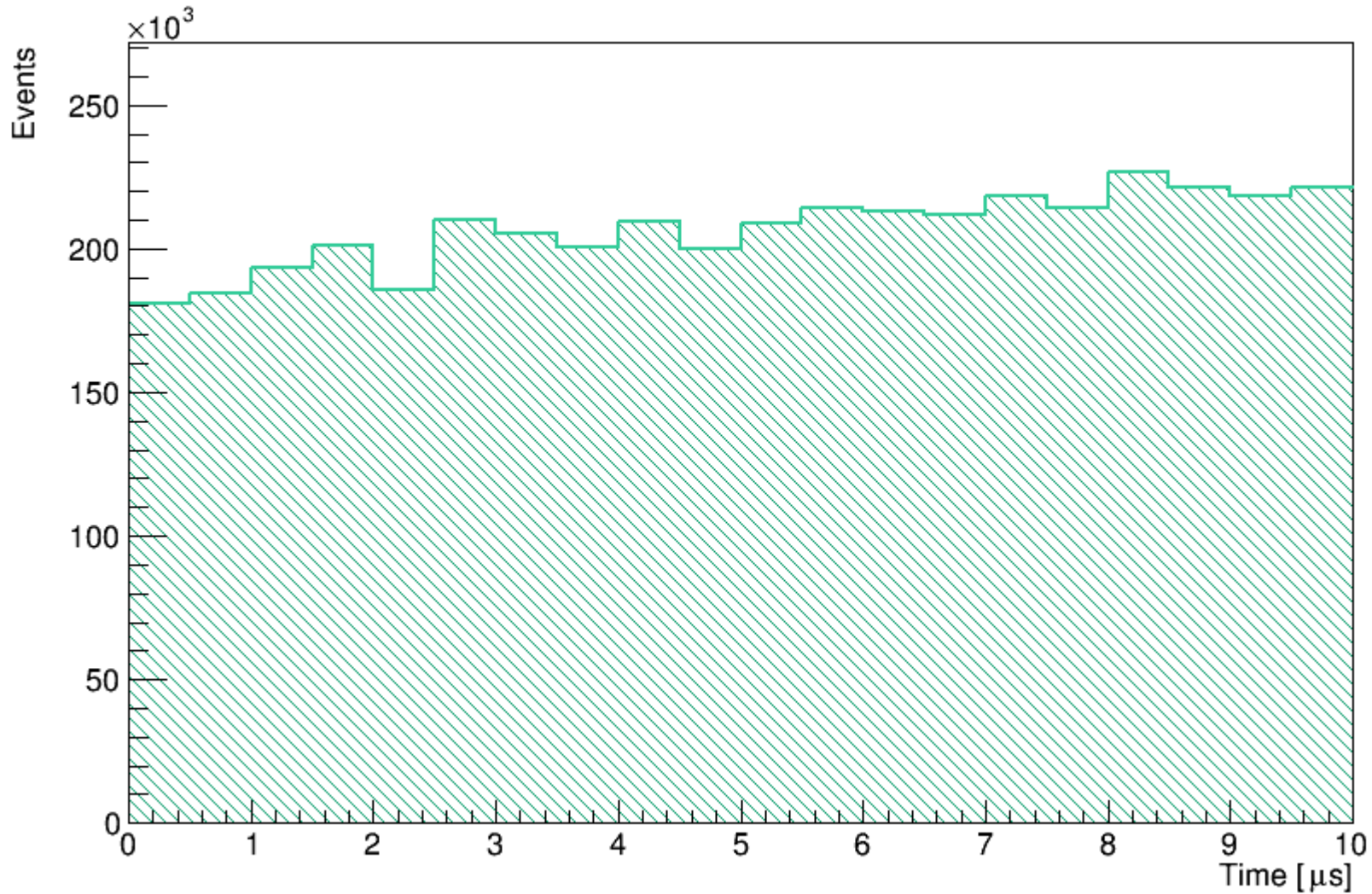


- Find the vertex
- Search for earliest hit satisfying lever arm & energy requirements



Background hit time distribution

Neutron hit time distribution

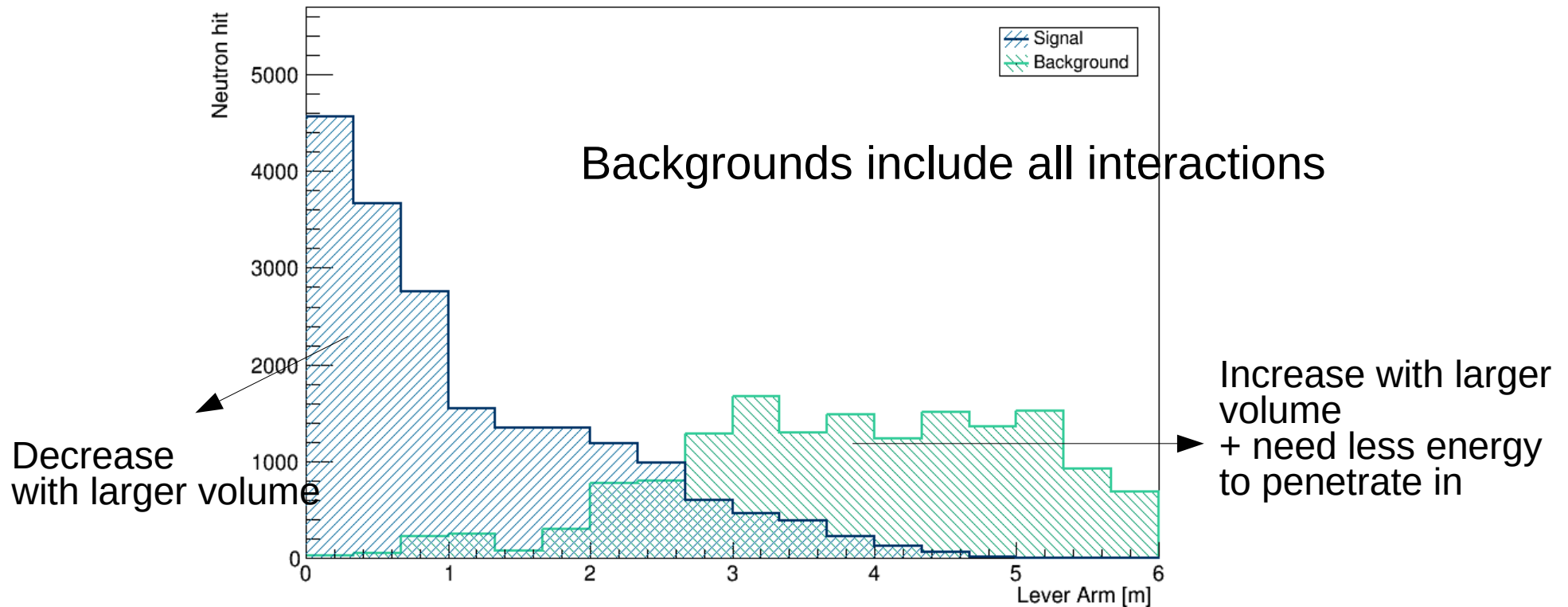




Signal and background vs. lever arm

- Find the FV vertex
- Plot neutron-induced hits along lever arm for signals and backgrounds

Neutron hit vs. Lever Arm



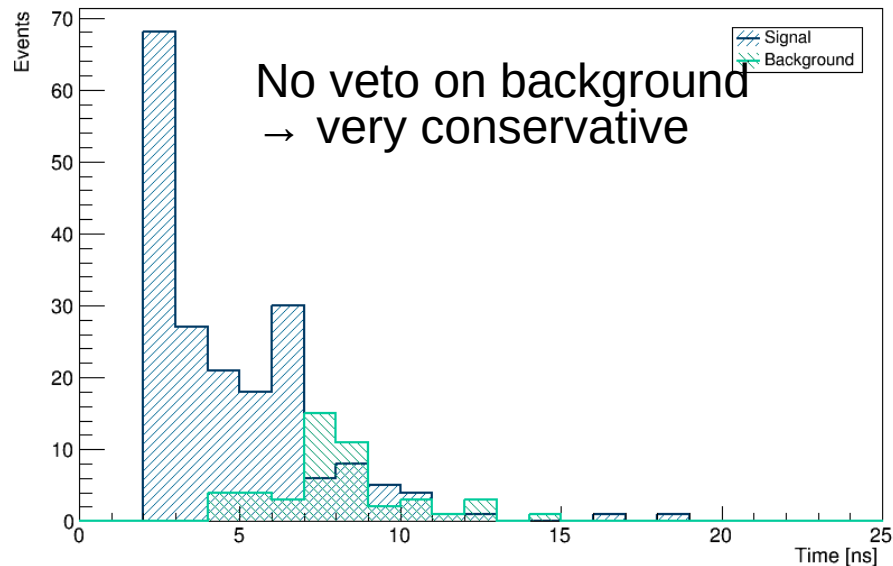


Hit time and lever arm

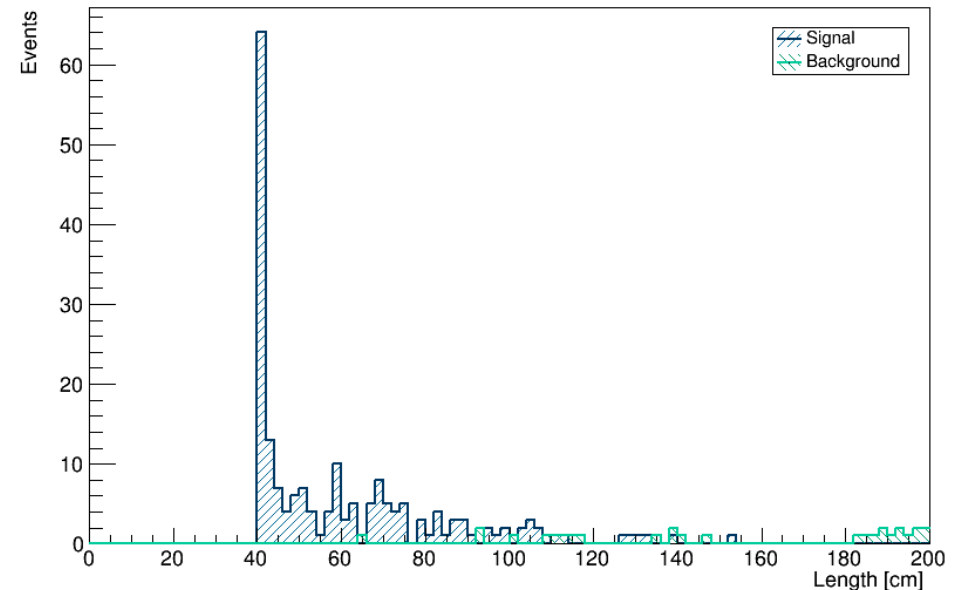
~4,000 spills

>40 cm lever arm

Time distribution



Lever Arm



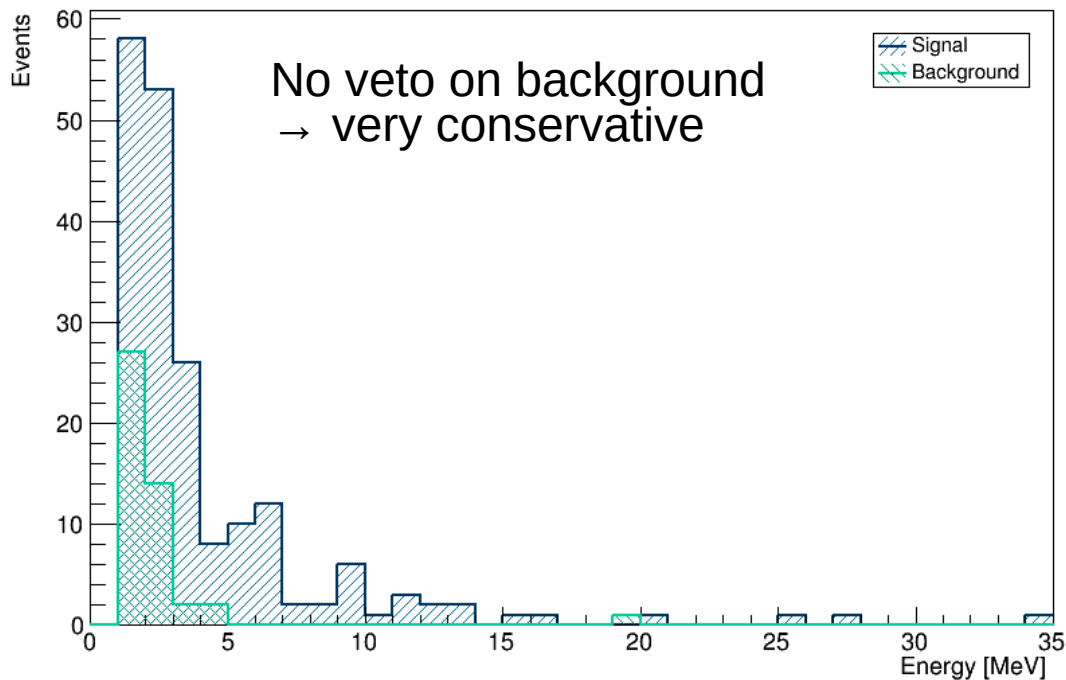
- Only looking for earliest neutron-induced hit
- With iron magnet + 1.5 MeV deposit threshold + all NC+CC in ECAL/Magnet/front detector/Rock considered as background
- Time is not very large to allow outside background hits coming in.



Signal vs. background

~4,000 spills

Neutron energy deposit



Origins of backgrounds:

TPC	0
ECAL	12
Magnet	4
Front detector	30
Rock	0

- With iron magnet + 1.5 MeV deposit threshold + All CC+NC in ECAL/front detector/Magnet/Rock considered as background
- Front detector gives a significant amount of background
- Swapping the TPC and ECAL helps reducing ECAL BGs.



Conclusion

- As shown before, we could control the neutron background reasonably well.
- Front detector is the main source of neutron background.
 - We could have a ToF detector in front of the cubes
 - We will do a more realistic gas TPC geometry.