Neutron transport simulation in AliRoot Framework

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Outline

In the present work AliRoot interfaces to particle transport simulation codes -GEANT3 and Fluka- are tested. Special emphasis on neutron transport was made checking its influence on several detectors in ALICE configuration. An extensive characterization of neutrons generated in ALICE barrel detectors and structures and its progeny was done when simulating HIJING events. Hits and digits distributions were compared. For GEANT3, a higher digit population related to neutrons was found.

- GEANT3 neutron transport mechanism.
- Neutron background sources in ALICE.
- Gamma spectrum divergencies
- Implications on hits and digits production.

GEANT3 neutron transport mechanism.

- In GEANT3, cut-off for neutrons transport is 20 keV
- Born above threshold.
  - Collisions down to threshold cut.
  - *At threshold cut forced radiative capture.*
- Born bellow threshold -production cuts are not followed-.
  - *Forced radiative capture.*

Forced radiative capture is implemented to improve deposited energy balance. Bare in mind that neutrons bellow 1 MeV can deliver important amount of energy.

What problems can be addressed?

- An unwanted and unphysical gamma field related to neutral hadrons,
- Some bias due energy threshold setting for neutron transport cut-off

The first should provoke a background hit population related to ghost photons and the latter an instability in the characteristics of such population either geometrical or its energy distribution.

Simulation Set Up.

- Detectors and structures
  - ITS, TPC, TRD, TOF and PHOS detectors.
  - ALICE structural components (PIPE, ABSO).
- Magnetic field in the barrel was set to 5 kG.
- Parametrized Hijing event
  - 5 events.
  - Vertex position (0,0,0)
  - ϕ direction and pseudo-rapidity range (η) uniformly distributed, the latter from 3 to -3 and -8 to 8 -consequently increasing particle number-
  - momentum range [0,999] and [0.02,999], depending on η.
- Neutral hadrons energy cut-off transport was manually set to 0, 100 keV, 1 and 30 MeV.

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Code Versions.

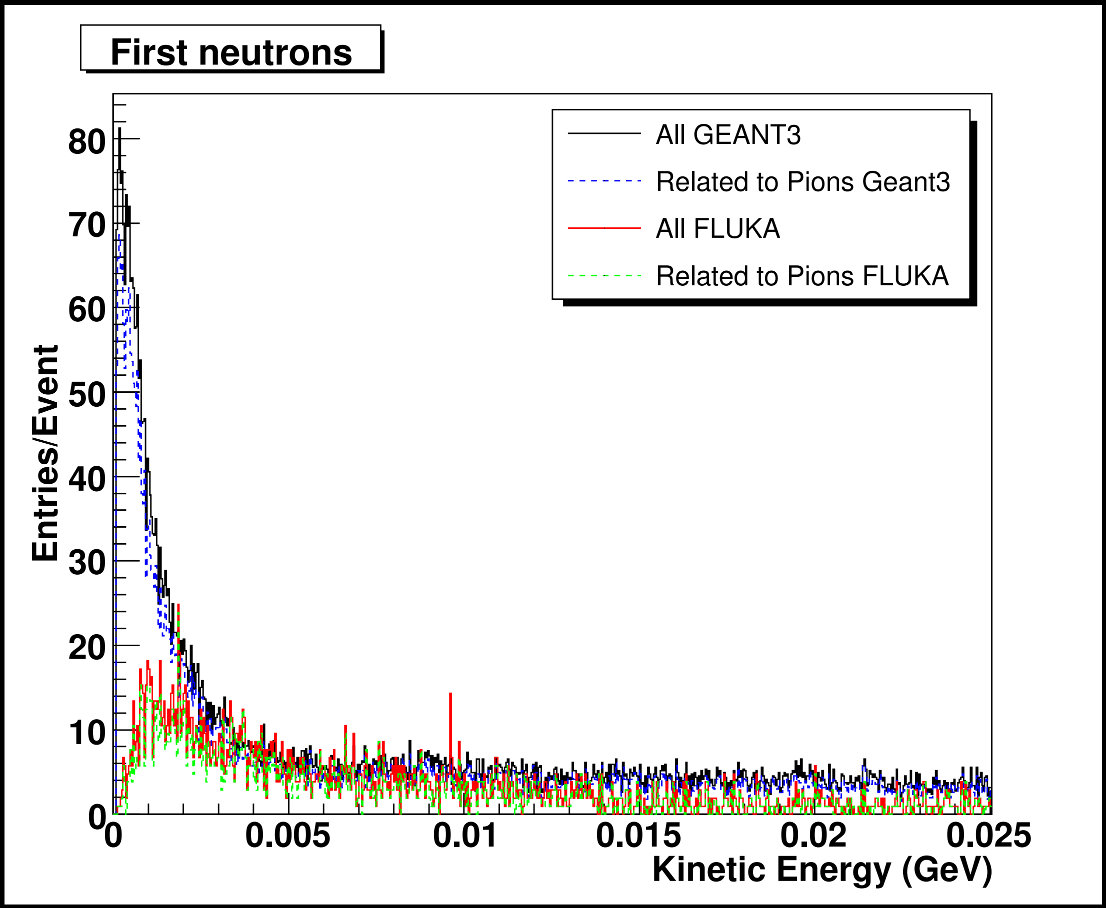
- Geant3 updated on October 27, 2005 (head version)
- Fluka release version 2005.6.
- AliRoot: Release 4.03.07.
- Root: Release 5.8.

Neutrons on Stack

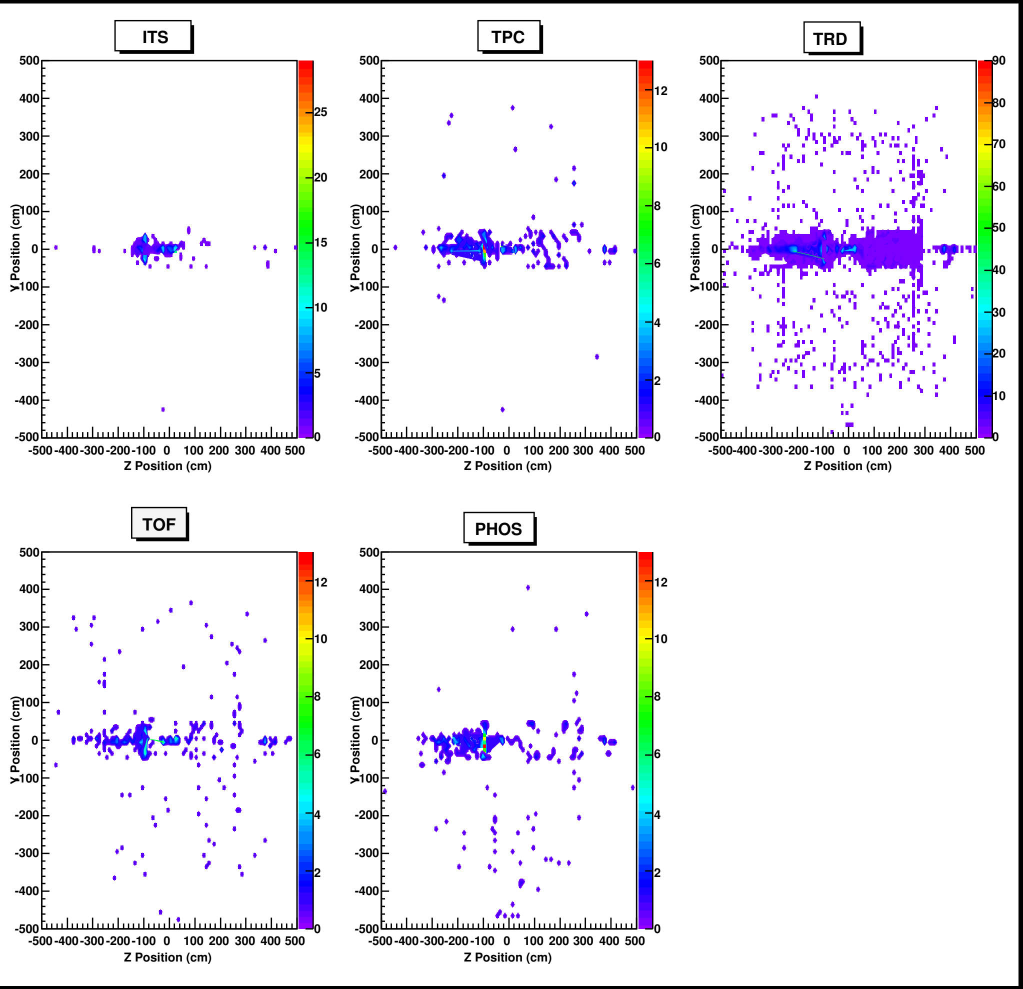
- Geant3
  - After each interaction neutrons ID change.
  - Elastic scattering 1 new neutrons stacked.
  - (n,2n) 2 new neutrons stacked
- Fluka
  - After each interaction neutrons ID don't change
  - Elastic scattering no new neutrons stacked.

As a consequence, GEANT3 neutrons population on stack is not comparable to Fluka. For comparative reasons, only first neutron in a chain is accounted.

Energy distribution of first neutrons

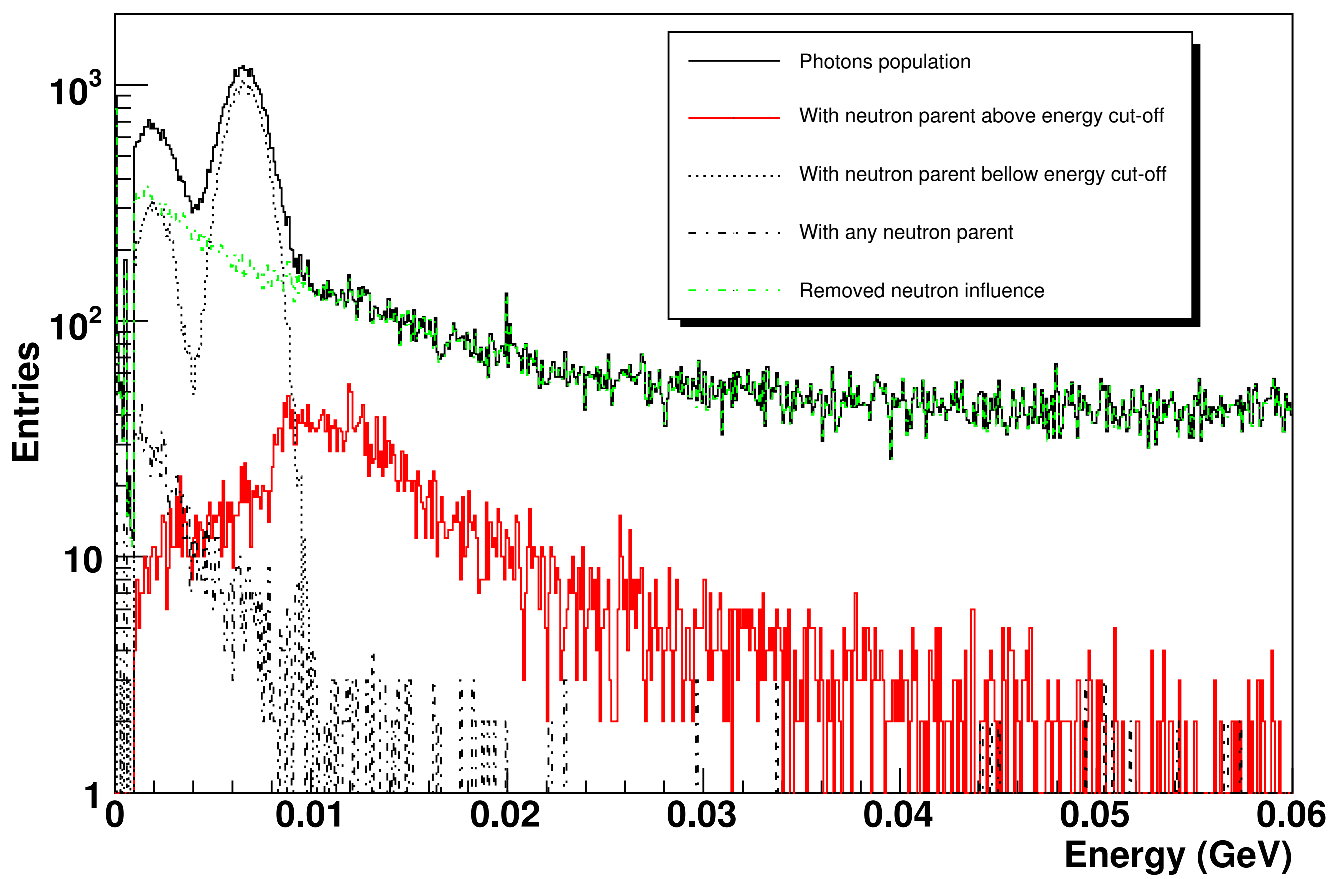


Neutron Vertex Production in GEANT3 above 1 MeV cut off and η in $[8, -8]$ range: YZ Projection

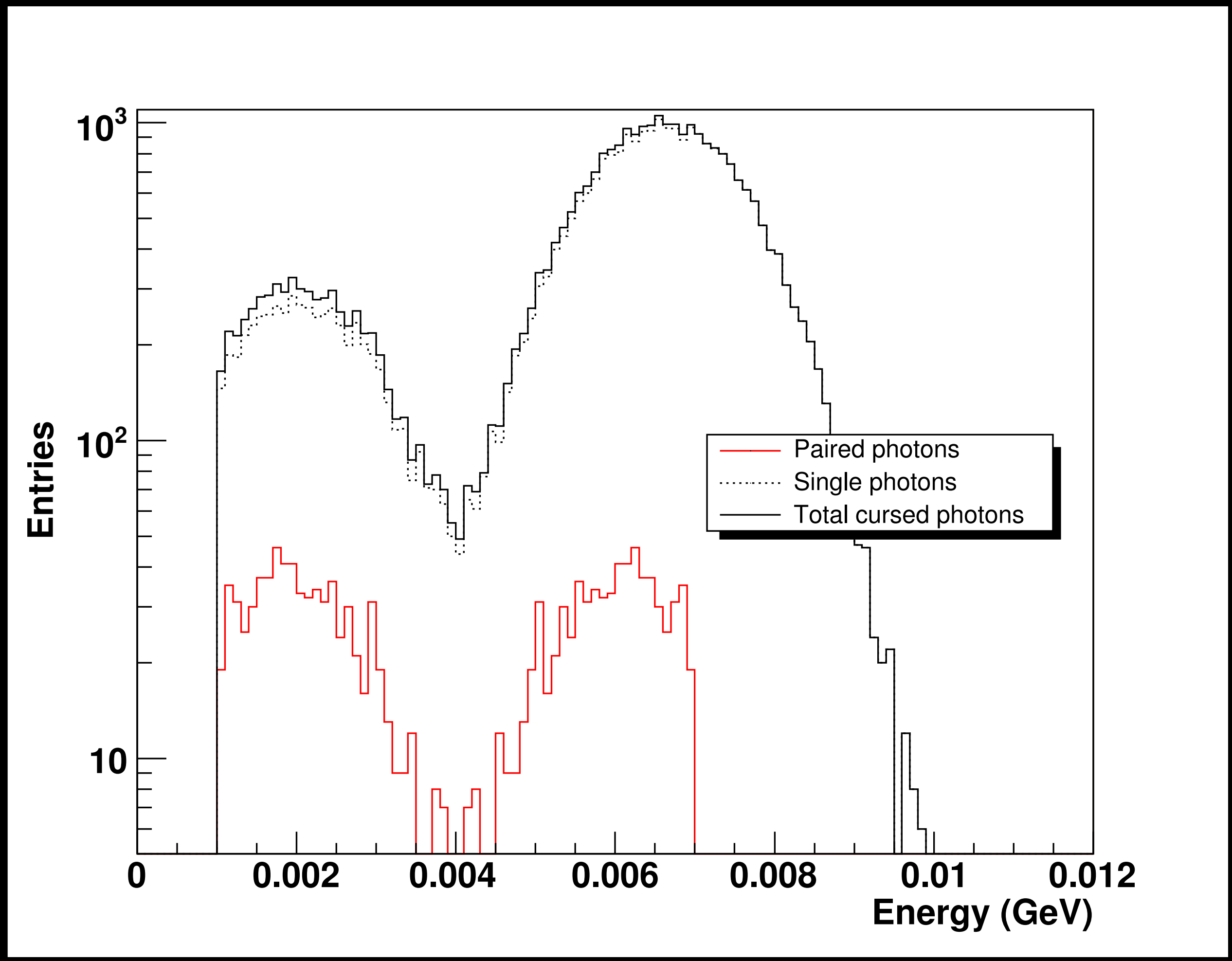


What about forced radiative capture in GEANT3?

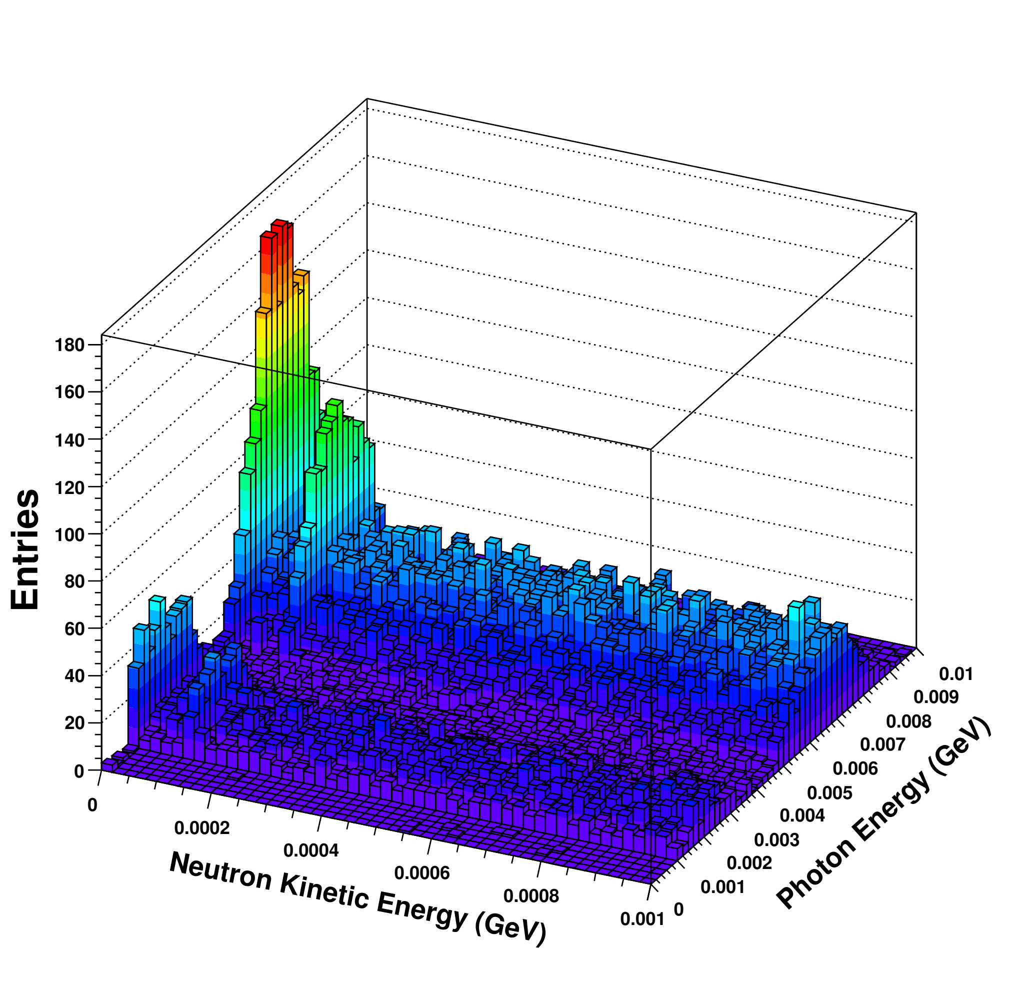
Full Photon spectrum in GEANT3.



Photon spectrum induced by neutron forced radiative capture in GEANT3.



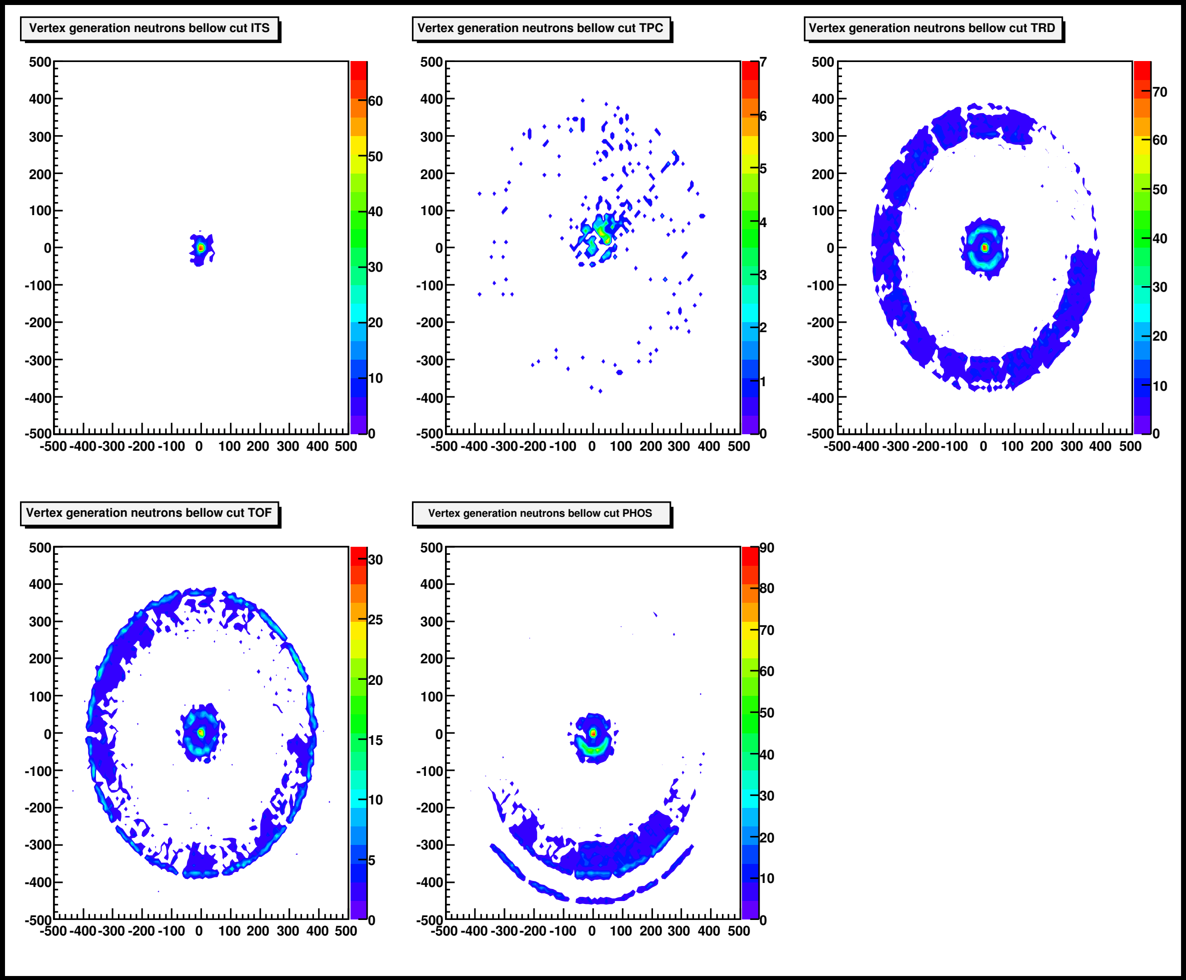
Correlation of photon spectrum due forced capture to parent neutron kinetic energy in GEANT3 for 1 MeV cut off.



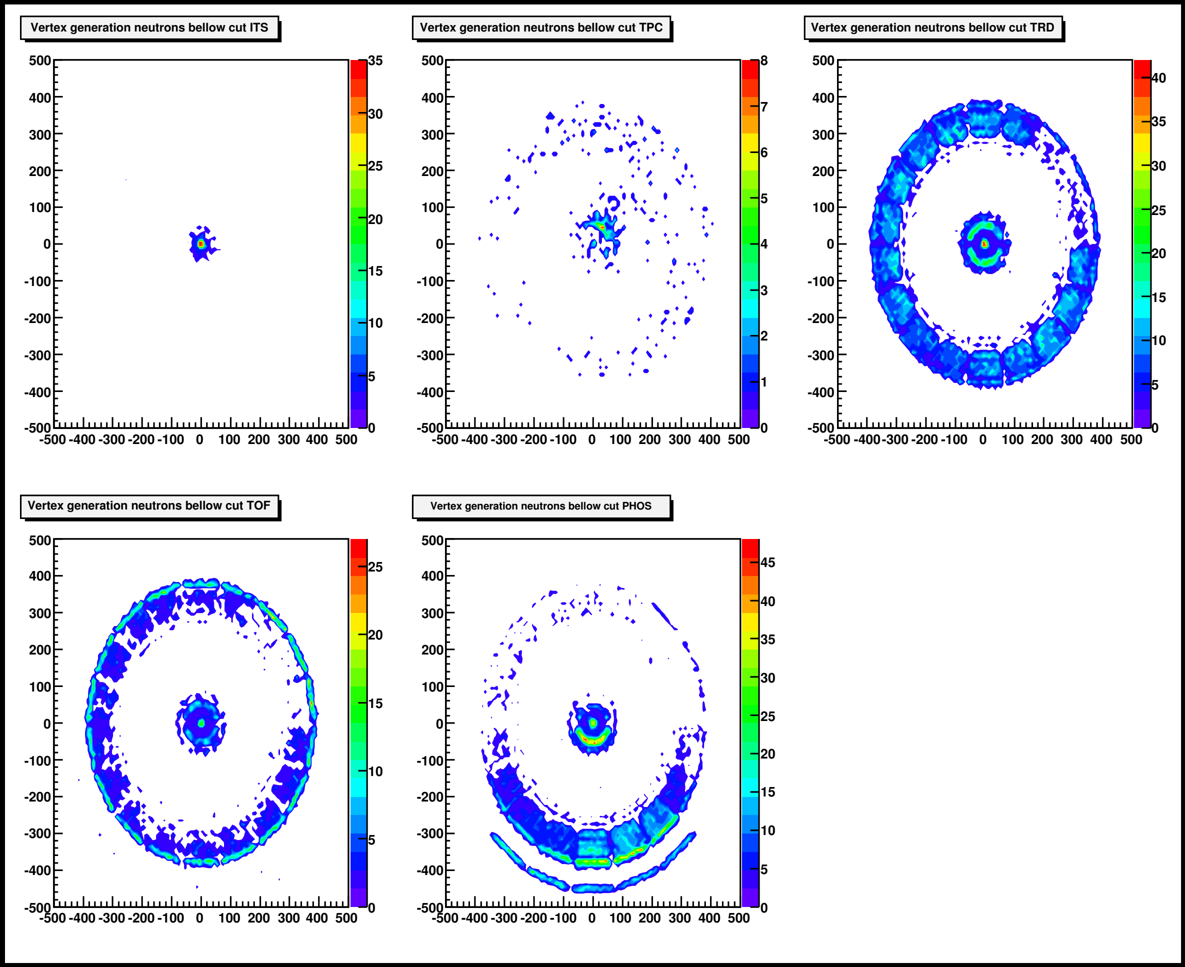
Characteristics of the forced γ spectrum in GEANT3.

- Single photon or scarcely paired.
- Independent of the transport cut-off for neutrons.

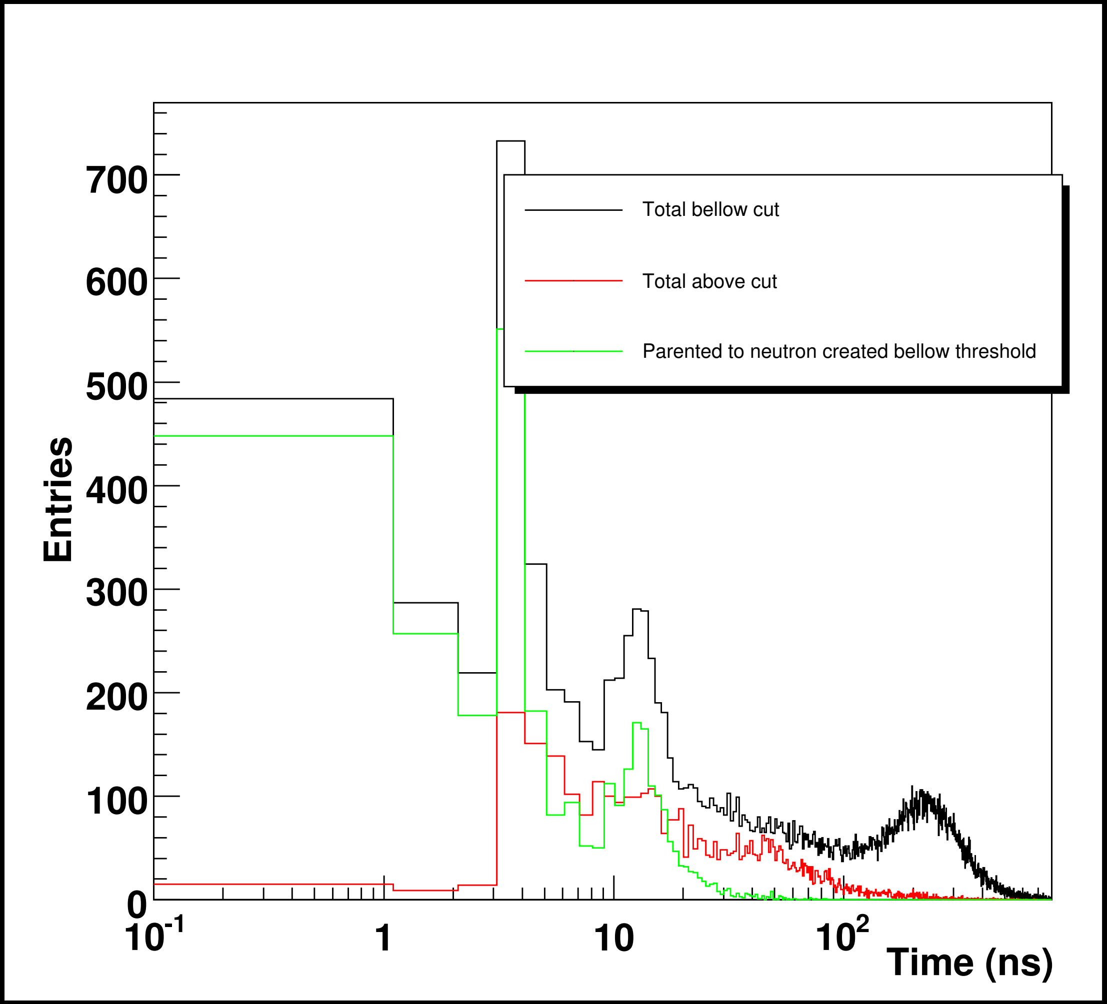
Vertex creation of γ from forced capture in GEANT3 for 1 MeV cut off affecting detectors: XY Projection



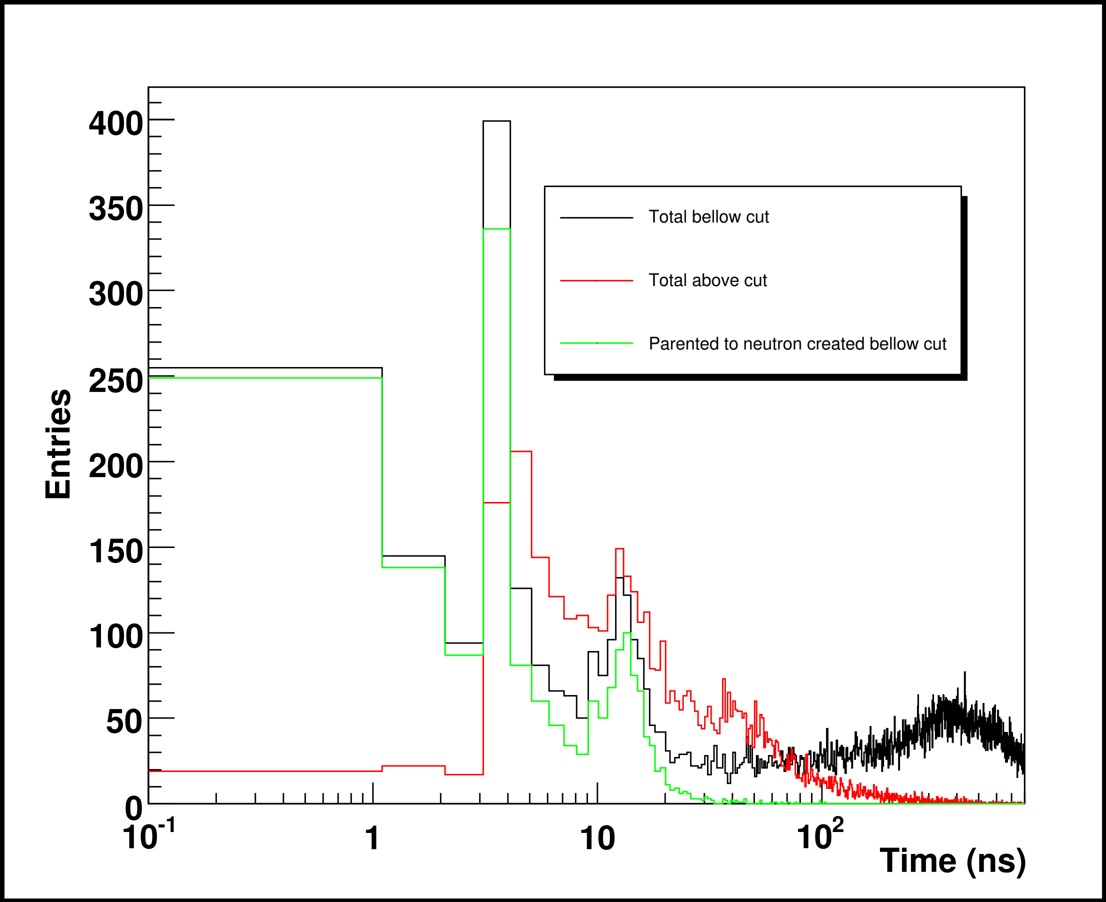
Vertex creation of γ from forced capture in GEANT3 for 100 keV cut off affecting detectors: XY Projection



Photon vertex creation timing in GEANT3 for 1 MeV cut off affecting detectors.



Photon vertex creation timing in GEANT3 for 100 keV cut off affecting detectors.

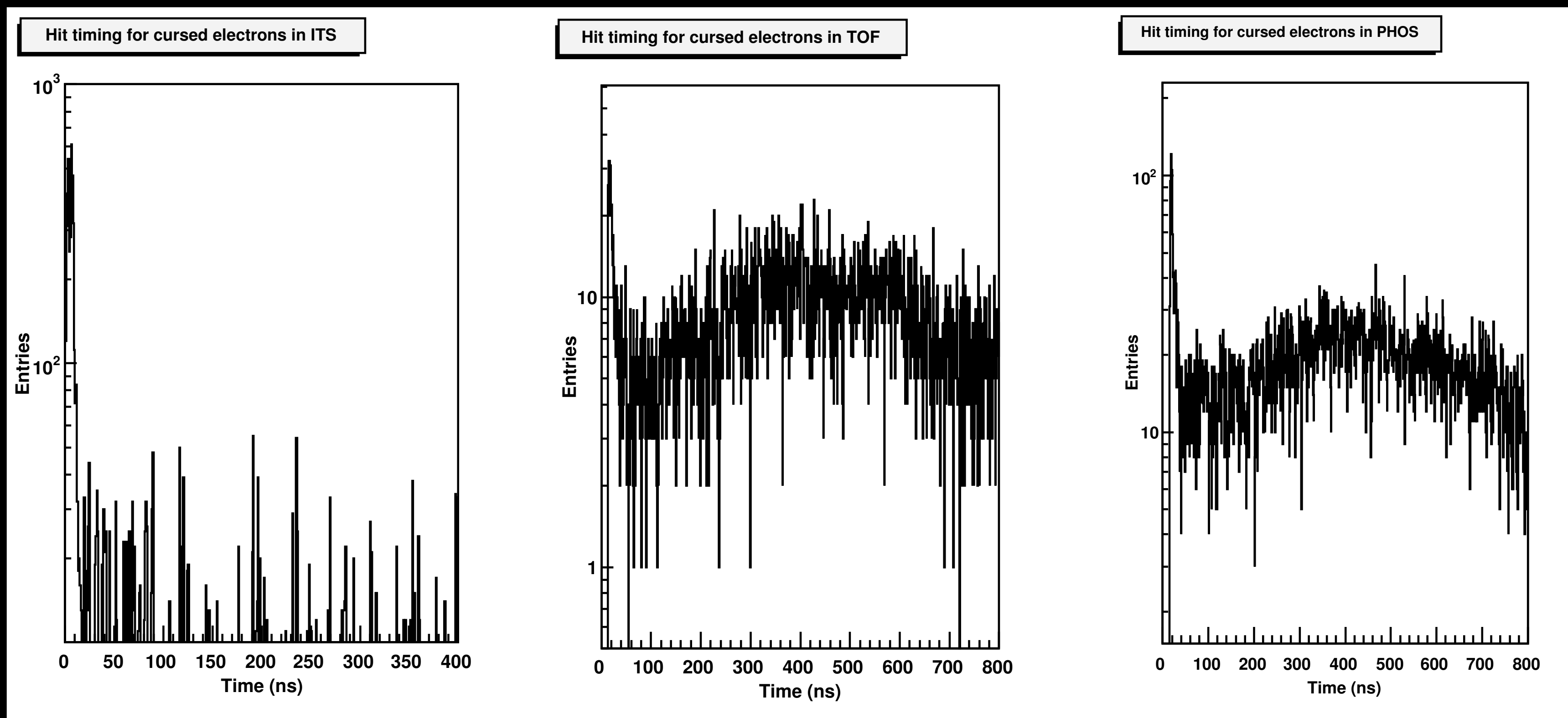


Characteristics of neutrons bellow transport cut for GEANT3.

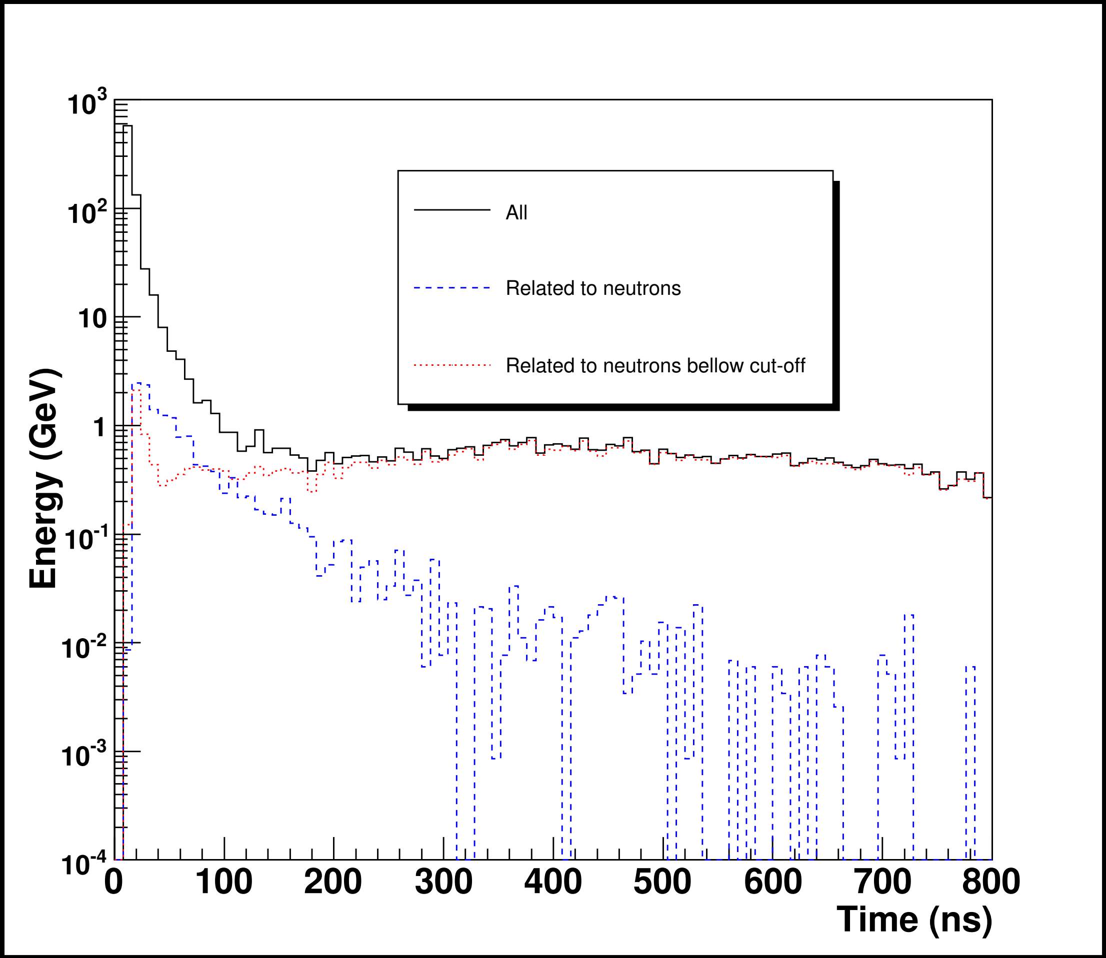
- Some neutrons are created bellow transport threshold.
  - *Parented mostly to* π^+, π^- *and p.*

Hit structure.

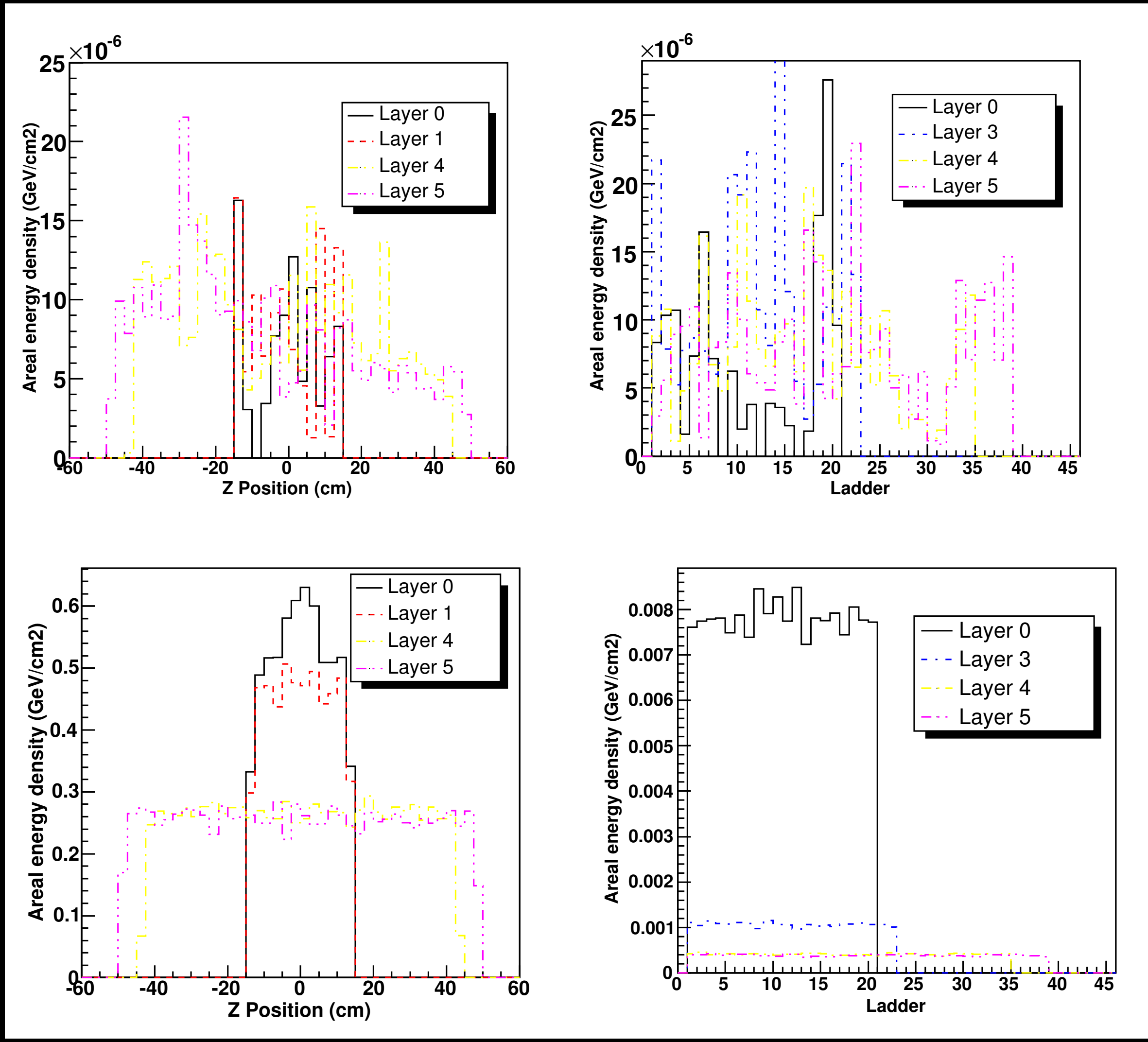
GEANT3: Hit time structure for 100 keV cut-off.



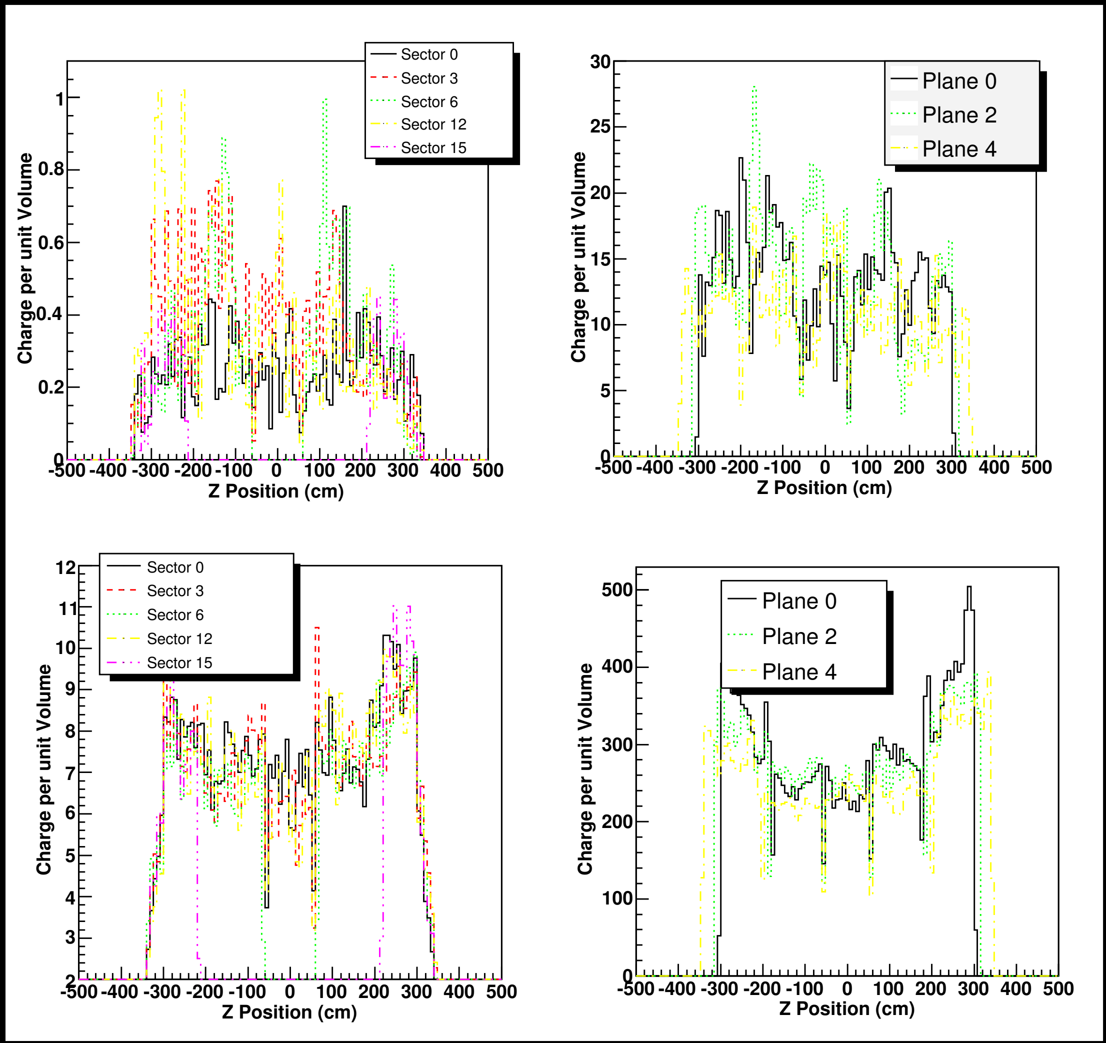
PHOS: Deposited energy of electrons and photons as a funtion of time in GEANT3 simulation for 100 keV cut off.



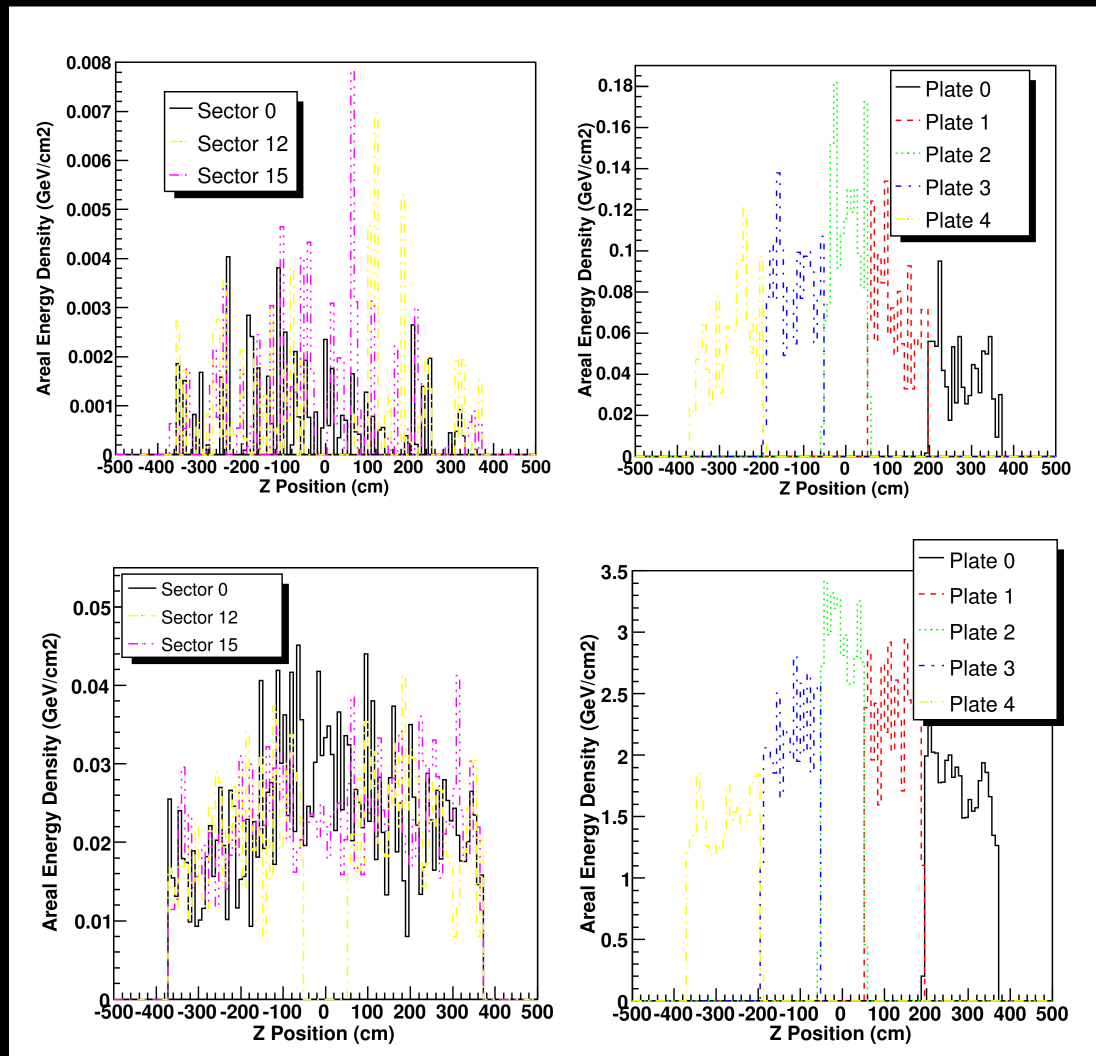
GEANT3: Spacial distribution in ITS



GEANT3: Spacial distribution in TRD



GEANT3: Spacial distribution in TOF



Neutron background and digits

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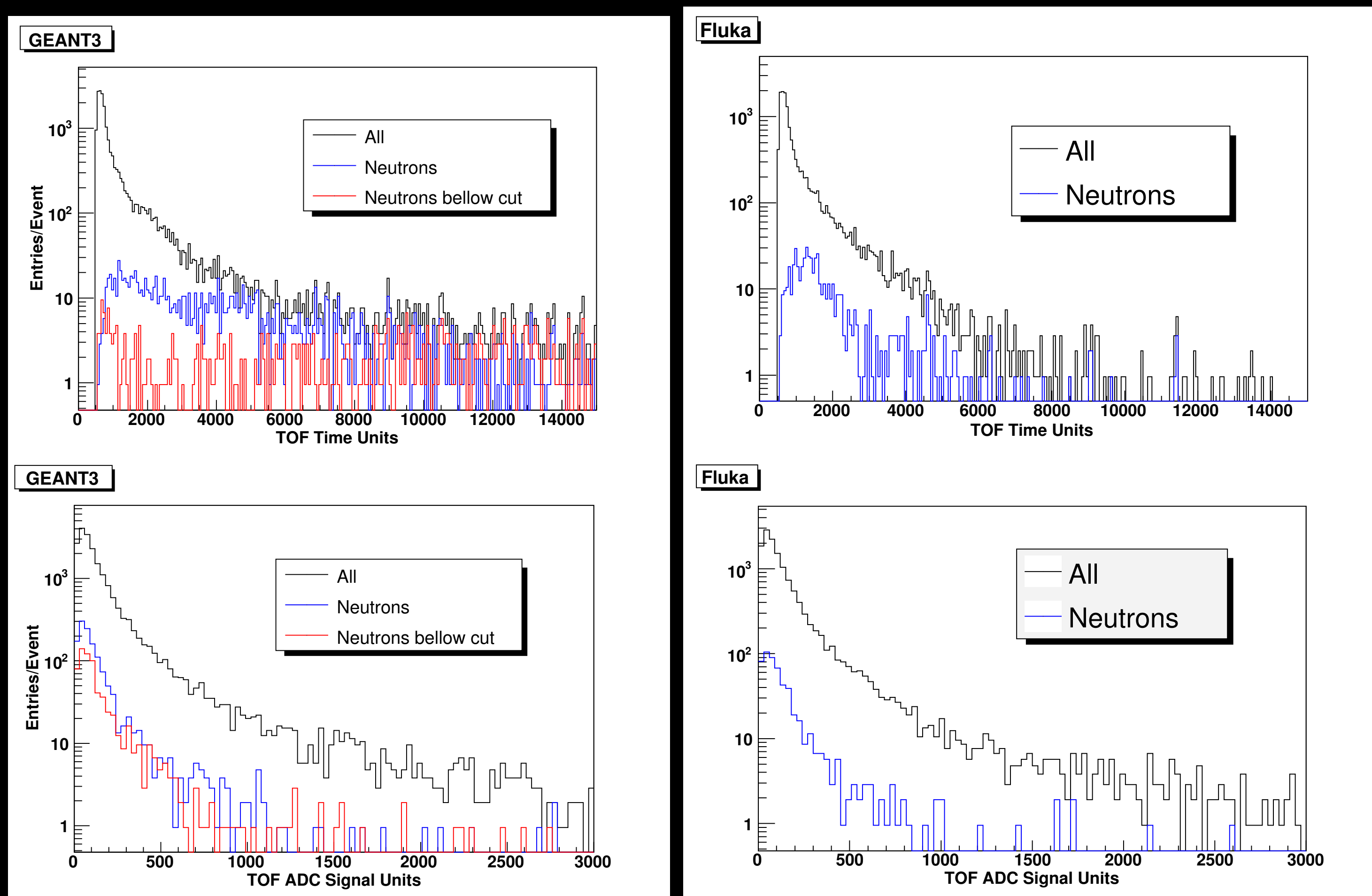
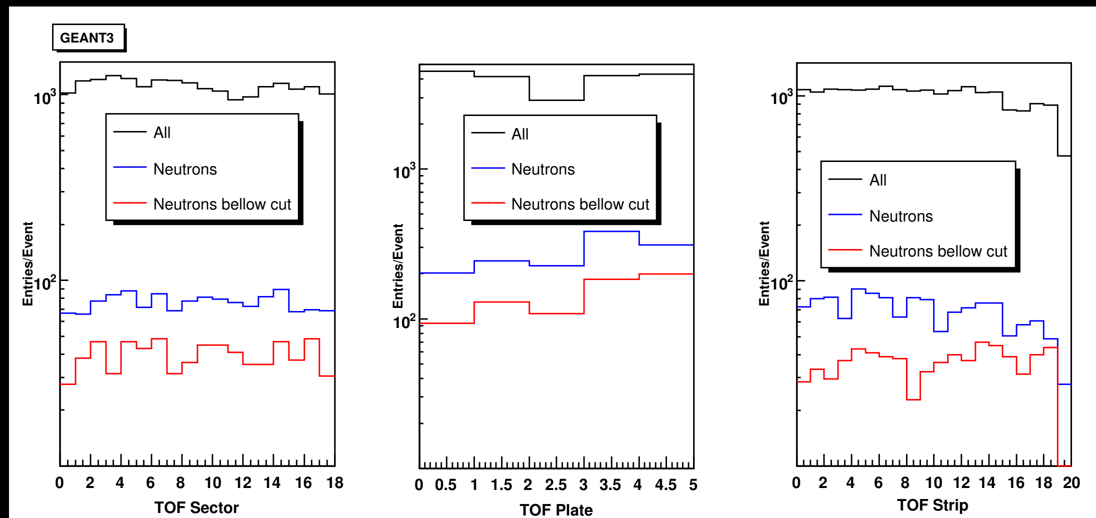
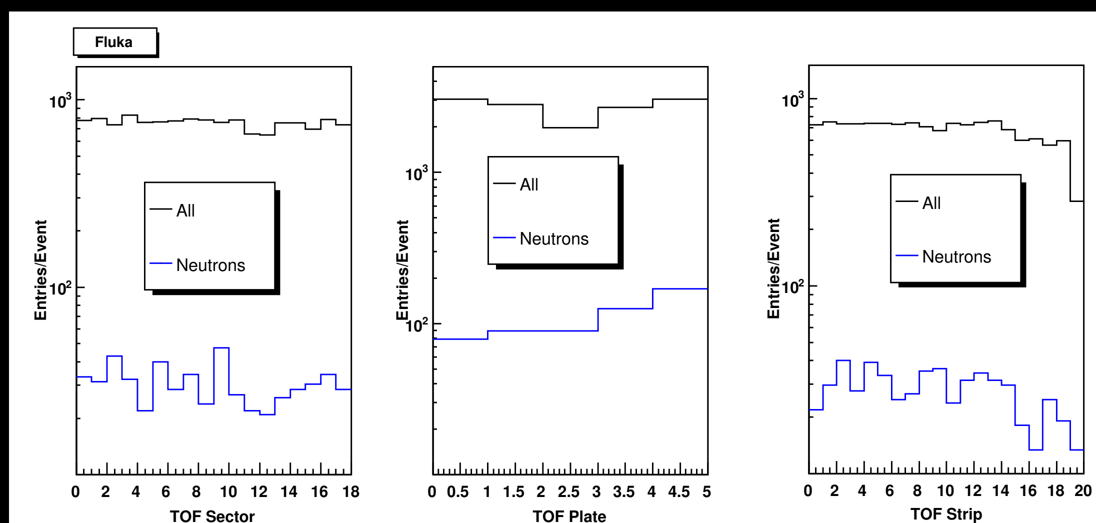
TOF digits amplitude and timing

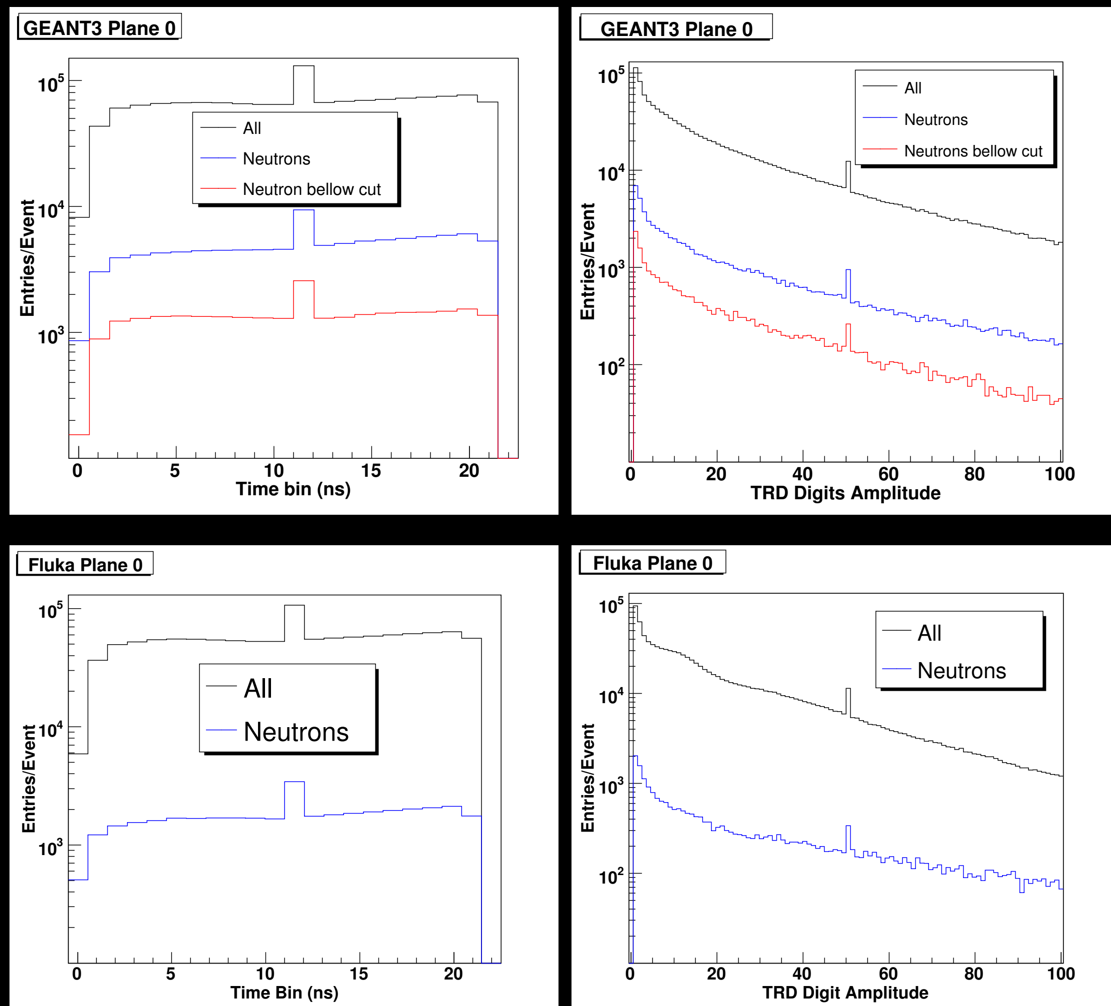


TOF Geometry

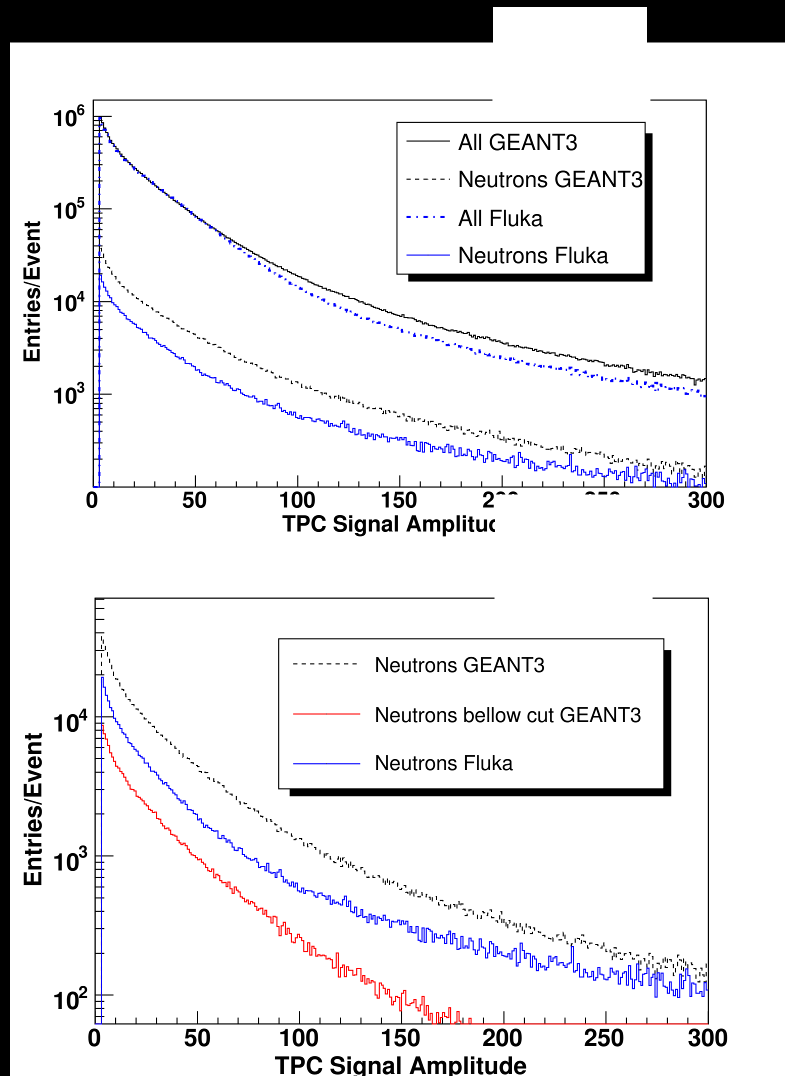




TRD Geometry



TPC Digits Amplitude



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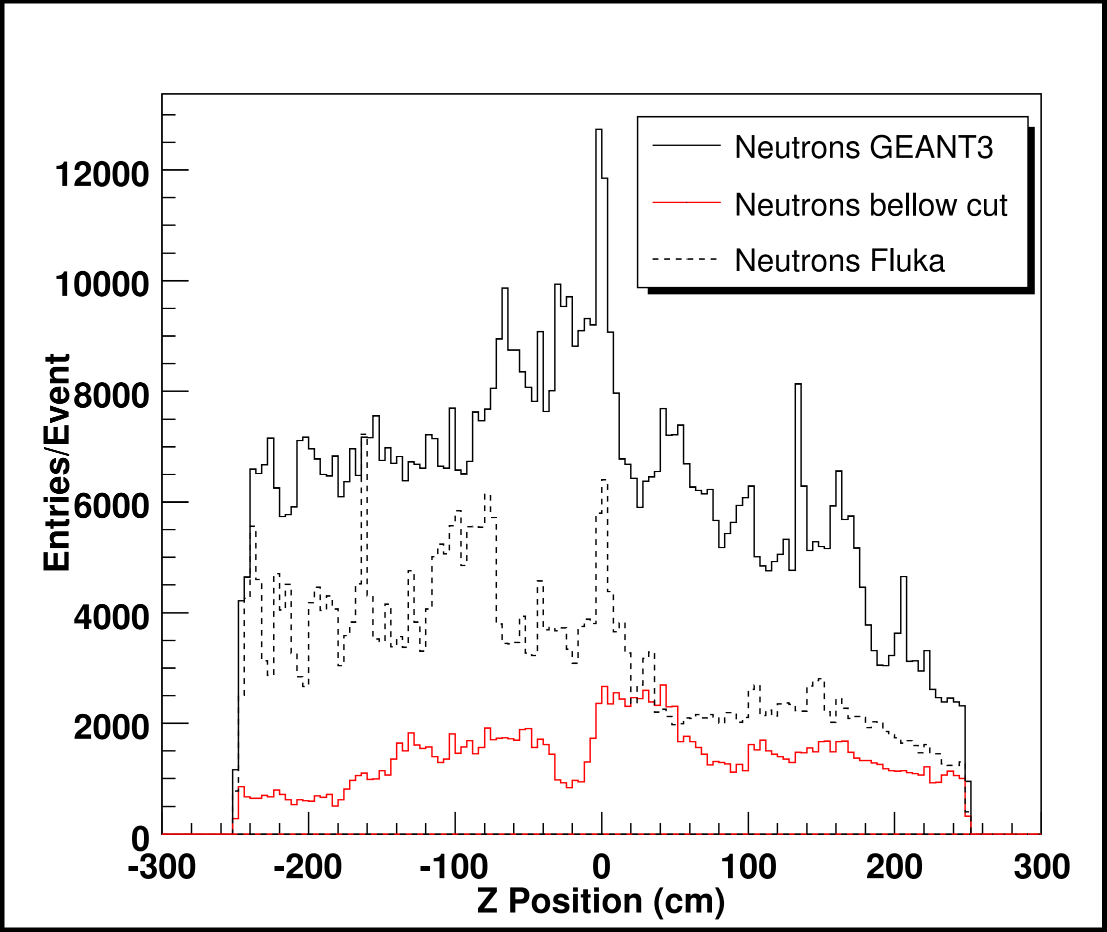
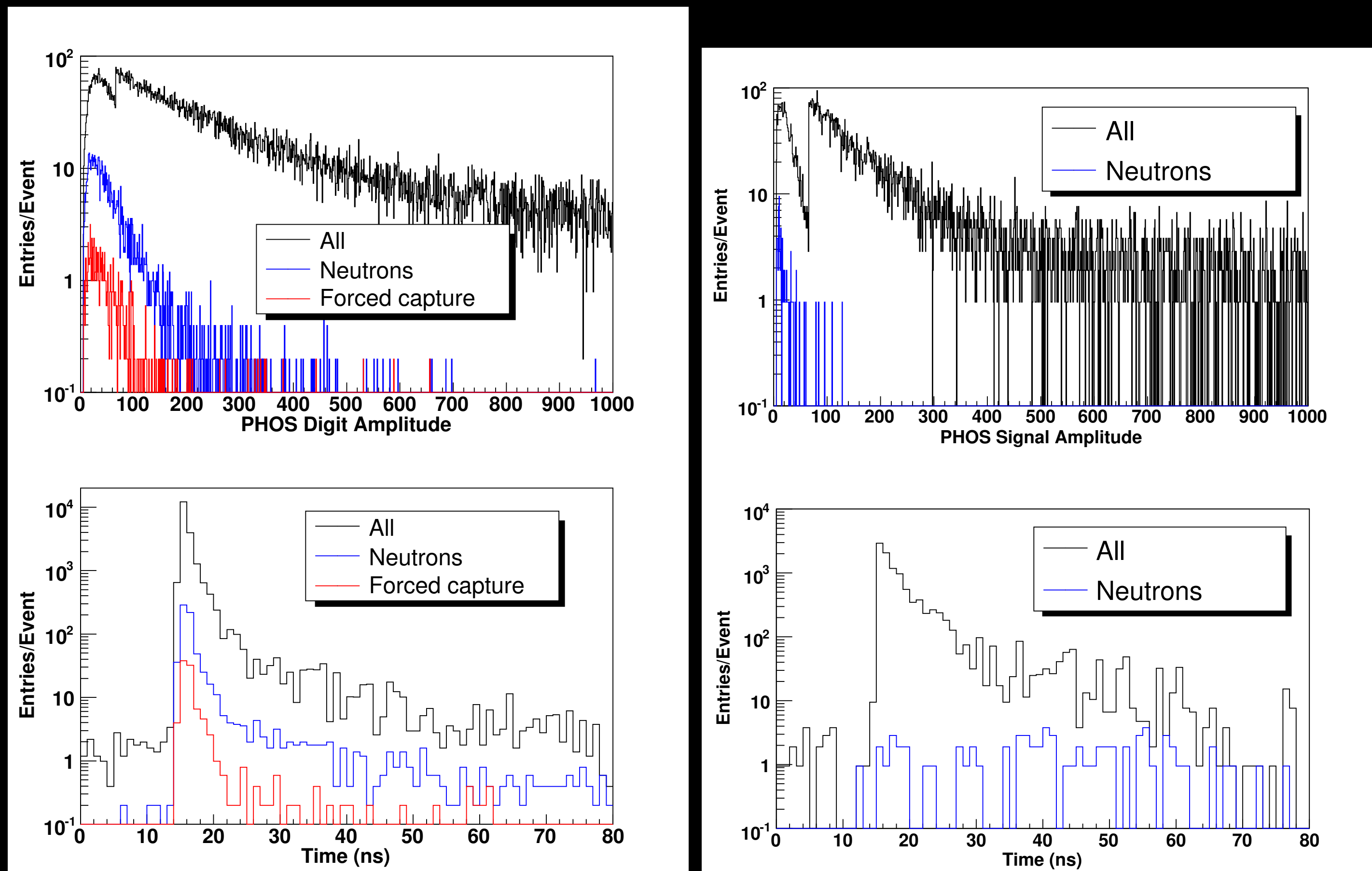
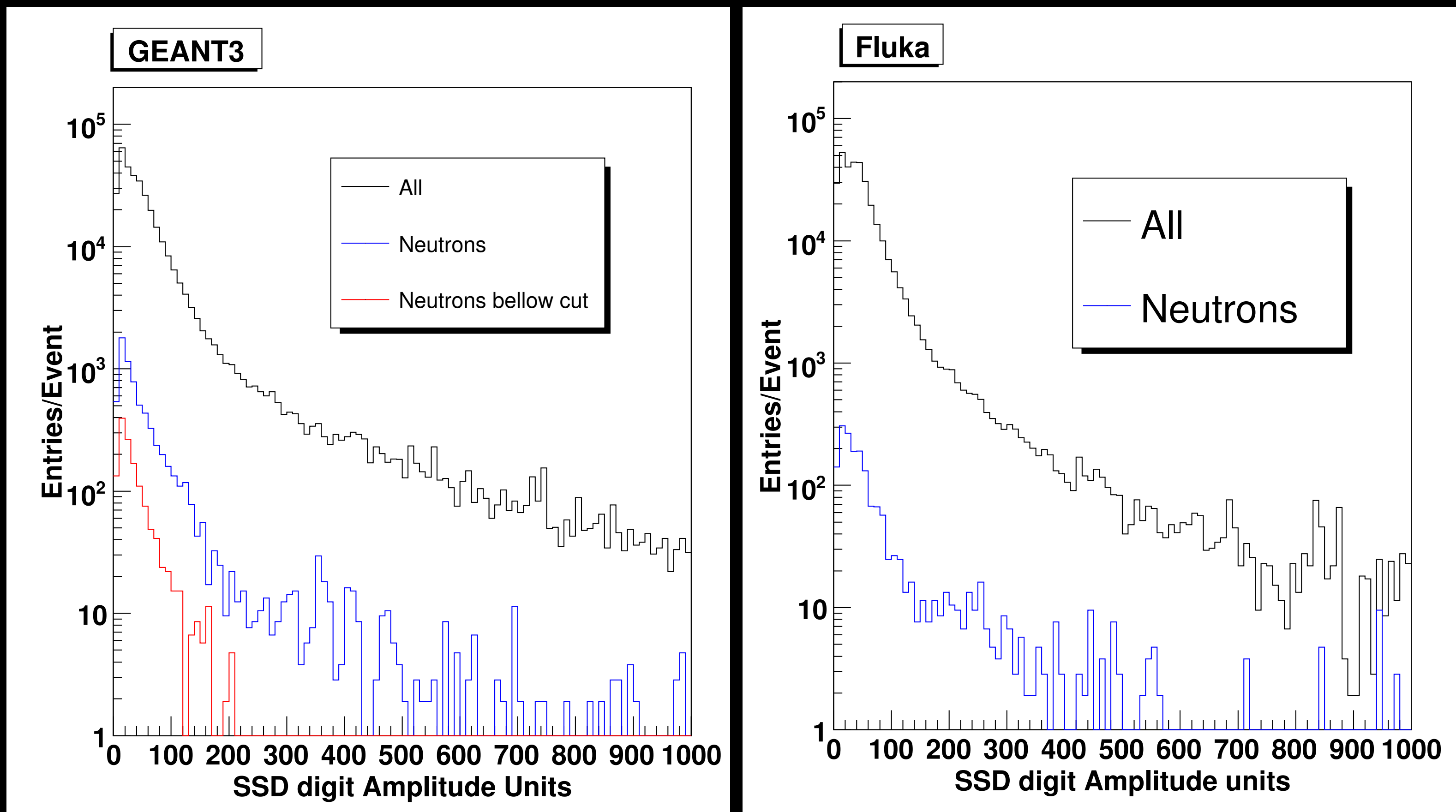
TPC Digits Z Position



PHOS Digits Amplitude



ITS Digits Amplitude



Last remarks.

- neutron population can not be directly described from the stack.
  - *GEANT3 interface to AliRoot put neutrons on stack on last scattering processes, right after falling down neutral hadron transport threshold, and in intermedial collisions*
- A second source of neutrons production bellow threshold occurs in the first 20 ns after the collision.
  - *Such population is mainly created by interactions of pions and protons with nuclei which create neutrons with kinetic energy bellow 20 keV.*

Last Remarks

- Neutrons population is estimated higher in GEANT3 than in Fluka.
- Even removing products from forced capture in GEANT3, current settings in VMC interfaces give a relation whole signals to neutron-related signal lower for GEANT3.
- Care must be taken when setting transport cuts per material for neutrons.