Background in the ALICE TRD due to neutron capture in Xe

G.Tsiledakis[1], A.Fassò[12], P.Foka[1], A.Morsch[2], and A.Sandoval[1]
[1]GSI,Darmstadt; [2]CERN,Geneva

ALICE at the CERN LHC, will study central Pb–Pb collisions at 5.5 TeV per nucleon pair which result in very high particle multiplicities. A high background of thermal neutrons is expected to build up as the particles shower and get stopped in the material of the detectors, magnets, support structures, and in particular in the concrete of the experimental cavern.

The Transition Radiation Detector (TRD) [1] is located in the ALICE central barrel inside the solenoidal magnet and will be used for electron identification and triggering on high-pt particles. It contains 6 layers of Xe gas with a total volume of 27.2 m^3 in the sensitive part of the detector. Some of the Xe isotopes have resonance peaks with very high neutron capture cross-sections (tens of kbarn) that lead to multi-gamma de-excitation cascades which can then produce low energy electrons through Compton scattering, photo-effect and conversion to electron-positron pairs, thus resulting in an event uncorrelated background.

The random background created during the 3 μs active gating time of the TRD chambers was estimated using the FLUKA [2] transport code. In order to study the effect of neutron capture in the Xe isotopes it was necessary to implement in FLUKA the calculation of (n,γ) reactions in Xe [3]. A new subroutine was then developed and integrated in the FLUKA code for the simulation of the full gamma cascade after neutron capture in all stable Xe isotopes. The results show that the most frequent lines belong to ^{132}Xe and correspond to energies 667.72, 772.60, 1317.93 and 6466.07 keV.

Events with average multiplicity of 80 000 primary pions and kaons were transported through the material of the experiment and experimental area which was described with about 3200 volumes.

Calculations were done with and without activating the neutron capture in Xe. Figure 1 shows the photon flux for both cases. One can see a much higher 511 keV peak (due to positron annihilation) in the case of activating neutron capture, as well as the most frequent gamma lines from the de-excitation of the compound nucleous ^{132}Xe. The 2.2 MeV peak from the neutron capture in H and the 7.9 MeV in Cu are identical, whether the neutron capture gammas in Xe is activated or not.

Results of energy density deposition and particle fluxes in one Xe layer show that:

- The total energy deposited is 4.32±0.31 10^{-5} GeV per primary particle. Of these the neutron capture in Xe contributes no more than 10%.
- The energy deposited from electrons, positrons and photons is 3.05±0.22 10^{-5} GeV per primary particle.
- The total neutron flux per primary in the TRD is 27±3 10^{-6} neutrons/cm^2.
- The thermal neutron flux per primary in the TRD is 8±1 10^{-6} neutrons/cm^2.
- The neutron fluence in the TRD per ALICE year is 3.5 10^9 neutrons/cm^2/year.

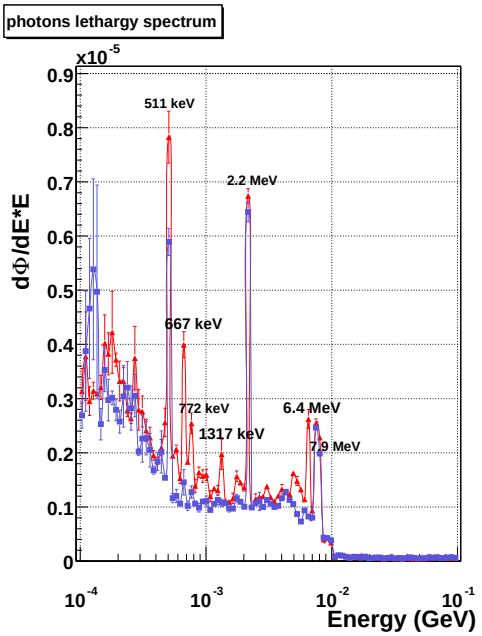

Figure 1: Photon fluence spectra in one Xe layer for one central Pb–Pb event, where the triangles correspond to the neutron capture in Xe activated and the rectangles without it.

Neutrons slowed down inside the detectors and surrounding material become thermalized and eventually, after several μs, some of them get captured. Therefore, for the background calculation, the delayed electrons which are produced after 10 μsec were taken into account and a minimum bias interaction rate of 8 kHz at a luminosity of 10^{27}cm^{-2}s^{-1} was assumed.

The total number of hits in a central Pb–Pb collision in a 3 μs window is a broad distribution with a mean of 7074 hits/layer and an rms of 15450/layer. Of these the random steady-state background contributes 26% as it produces extra hits in the Xe readout chambers with a mean of 1856 hits/layer and an rms of 907/layer. The neutron capture in Xe has as result a 22% increase in the background and a 6% increase in the total number of the hits.

The results show that the n-capture in Xe does not increase the background by a big amount but it is significant and will be included in the AliRoot simulations.

References

[1] *"Transition Radiation Detector"* ALICE Technical Design Report, CERN/LHCC 2001-021 (2001).
[2] http://www.fluka.org
[3] A.Fassò, A.Ferrari, P.R.Sala and G.Tsiledakis, *"Implementation of Xenon capture gammas in FLUKA for TRD background calculations"*, ALICE Internal NOTE 28-2001 (2001).