

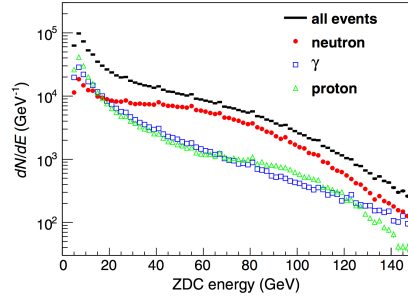
### 5.2.1 Previous simulation study

The background structure at ZDC in  $p+p$  collisions at  $\sqrt{s} = 200$  GeV was examined by PYTHIA6 [77] event generator with GEANT3 [78] for the previous publication [3] of Run-05 neutron  $A_N$  in  $p+p$  collisions. The apparatus in the simulation included the neutron detectors, the beam pipe, BBC, and the Dx magnet in front of the ZDC. Since there is a beam bending magnet in front of the ZDC, charged particles having nearly beam momenta are expected to be swept away from the ZDC acceptance, and only neutral particles are expected to be detected naively. However, some scattered protons could hit the ZDC as well.

At the 5 GeV ZDC energy threshold, 92% of events deposit a single particle at the ZDC. Multi-particles events are mainly consist of one neutron and one photon. This kind of events do not affect neutron position measurement because electromagnetic shower of photon stops in the first ZDC module, in front of the SMD, and they only increase the measured energy from the original neutron energy. This multi-particle effect is neglected in this analysis.

Physics process	Neutron ( $\mu\text{b}$ )	$\gamma$ ( $\mu\text{b}$ )	Proton ( $\mu\text{b}$ )
$qq \rightarrow qq$	35	46	14
$q\bar{q} \rightarrow q\bar{q}$	<1	<1	<1
$q\bar{q} \rightarrow gg$	<1	<1	<1
$gg \rightarrow gg$	268	358	95
$gg \rightarrow q\bar{q}$	9	12	3
$gg \rightarrow gg$	352	468	114
Elastic scattering	0	0	446
Single diffractive (XB)	<1	2	387
Single diffractive (AX)	462	527	107
Double diffractive	328	413	92
Low- $p_T$ scattering	551	651	137
Total	2006	2479	1395

(a) Production processes [79].



(b) ZDC energy distributions [3].

Figure 5.1: PYTHIA+GEANT: Event structure of main particles (neutrons, photons, and protons) at the ZDC acceptance at 5 GeV threshold.

Single particle events are mainly neutron, proton, and photon. Figure 5.1a summarizes their production processes. Figure 5.1b shows their ZDC energy