What ALICE Requires and Provides for Background Optimisation

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Abstract

This paper briefly discusses the ALICE machine background concerns and the background monitoring system.

ALICE RUNNING STRATEGY

ALICE (A Large Ion Collider Experiment) [1] is a general purpose detector designed to address the physics of strongly interacting matter and the quark-gluon plasma in nucleus-nucleus collisions at the LHC. It will allow a comprehensive study of particles produced in Pb–Pb collisions, up to the highest multiplicities anticipated at the LHC. The physics program also includes collisions with lighter ions as well as dedicated proton-nucleus runs. Regular data taking during pp runs will provide reference data for the heavy ion program and address a number of specific pp topics.

The pp runs will be in parallel with the other experiments but at a reduced luminosity in IP2. In order to keep the pile-up in the Time Projection Chamber (TPC) and Silicon Drift Detectors (SDD) at an acceptable level, the luminosity during pp runs has to be limited to $3 \times 10^{30}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$, corresponding to an interaction rate of $200\,\mathrm{kHz}$. At this rate we record on average 20 overlapping events. The optimal detector operation and physics performance with the TPC, i.e. no pile-up, is at $10^{29}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$.

IMPACT OF MACHINE BACKGROUND

General considerations

Due to the running at reduced luminosity ALICE has the most unfavorable interaction rate over background rate ratio (at least a factor of 10^3 less than the high luminosity experiments). Machine background effects are alleviated by the fact that ALICE has been designed to perform tracking for up to 1000 times the pp multiplicity and the trigger reduction factors are relatively small (typically 10^3). So far the expected effects of the background are mainly of cumulative nature, such as radiation damage (integral dose and neutron fluences). Also the increase of the data volume has obvious negative consequences in terms of data storage and offline computing requirements.

To simulate these effects ALICE has so far considered beam gas events in the experimental region IP $\pm 20\,\mathrm{m}$ and beam-halo from beam-gas scattering outside the experimental regions. Input for the quartiary background caused by tertiary collimators (TCT) close to the experimental region is not yet available for IP2. In case the collimators are at the nominal settings this contribution could well be the dominant source of machine background. However, since at full beam intensity ALICE will run at high β^* ($10\,\mathrm{m}$), the inner triplet will not limit the aperture of the machine. ALICE requires that for stable beams the TCTs will be put at a position at which they protect the inner triplets against accidental losses but do not produce extra losses for stable beams.

Dose in central detectors

The radiation environment in the experimental cavern has been simulated for the planned running scenario of the ALICE experiment (Table 1) [2]. Running with p-p, low and high mass ion–ion collisions over a ten year period has been assumed. Beam-beam and beam-gas interactions have been considered as potential radiation sources. The highest doses, up to 2.8 kGy, are expected at the location of the inner tracking system (ITS) (Table 2). The contribution from beam halo [3] amounts to $\approx 20\%$ of the total dose. The contribution from beam-gas collisions within the experimental region has been calculated assuming a very conservative residual gas pressure of $2 \times 10^{13}\,\mathrm{molecules/m}^3$. Only under these conditions a sizeable contribution of about 10% of the total dose is expected.

Charged particle rates on RPCs

Among the ALICE detectors, the muon trigger system is one of the most sensitive to the machine induced background. As a matter of fact, the Resistive Plate Chambers (RPC) rate capability ($50 - 100\,\mathrm{Hz/cm}^2$) might be saturated by a too high background level, which might also have an impact on the detector lifetime. The fluxes of secondary charged particles through muon trigger system originating from machine induced background has been simulated [4]. The trigger background consists mainly of electrons from hadronic showers resulting in a hot spot of $\approx 60\,\mathrm{Hz/cm}^2$ located at $x = 1.5\,\mathrm{m}$ and $|y| < 1.5\,\mathrm{m}$.

BACKGROUND MONITORING

For machine background monitoring during injection ALICE will use the beam condition monitor (BCM) and the V0 forward scintillator detectors at safe photomultiplier settings. Due to the different acceptance of the two detectors an OR of the two signals will be used. With circulating stable beams a combination of signals from BCM, V0, SPD, TPC and forward muon spectrometer will be used to obtain a normalized machine background signal.

Beam condition monitors

The purpose of the Beam Condition Monitor (BCM) is to detect adverse beam conditions within the ALICE exper-

Table 1: Operation scenario for a ten-year run period, where $\langle \mathcal{L} \rangle$ is mean luminosity, and σ_{inel} is the inelastic cross section. One year of pp run corresponds to 10^7 s and one year of heavy-ion run corresponds to 10^6 s.

	pp	Ar–Ar	Ar–Ar	Pb–Pb	dPb
$\langle \mathcal{L} \rangle$ ($\mathrm{cm}^{-2}\mathrm{s}^{-1}$)	3×10^{30}	3×10^{27}	10^{29}	10^{27}	8×10^{28}
σ_{inel} (mb)	70	3000	3000	8000	2600
Rate (s^{-1})	2×10^5	9×10^3	3×10^5	8×10^3	2×10^5
Runtime (s)	10^8	1.0×10^6	2.0×10^6	5×10^6	2×10^6
Events	2×10^{13}	9×10^9	6×10^{11}	4×10^{10}	4×10^{11}
Particles per event	100	2400	2400	14 200	500
N_{tot}	2.1×10^{15}	2.2×10^{13}	1.4×10^{15}	5.7×10^{14}	2×10^{14}

Table 2: Doses in inner tracking system

Detector	Dose [Gy] IP Collisions	Dose [Gy] Beam-Gas	Dose [Gy] Halo	Dose [Gy] Total
SPD1	2000	250	500	2750
SPD2	510	48	120	680
SDD1	190	12	45	250
SDD2	100	2.4	13	120
SSD1	40	1.2	7	50
SSD2	26	0.6	2.5	30

imental region. It provides active protection, in particular of the ITS, against multi-turn beam failures. The detector is based on pCVD diamond sensors ($1\mathrm{cm}^2 \times 500\,\mu\mathrm{m}$) and its design is a copy of the LHCb BCM [5].

BCM sensors have been installed at three different location, 4 sensors $z = 15.5\,\mathrm{m}$ (BCMA2), 4 sensors at $z = 4.5\,\mathrm{m}$ (BCMA1) and 8 sensors at $z = -19\,\mathrm{m}$ behind the small angle absorber. These loactions have been chosen since no other space is available on the muon spectrometer side. The advantage of the location is that the expected signals due to pp collisions and due to background events (beam-gas collisions in the experimental region, machine induced background) are of comparable intensity. Closer to the IP pp collisions are dominating.

V0 Detector

The V0 detector consists of two arrays of 64 scintillator tiles read out via fibers. V0A is located $340\,\mathrm{cm}$ from the IP on the side opposite to the muon spectrometer and the V0C is fixed at the face of the fron absorber, $90\,\mathrm{cm}$ from the vertex. The covered pseudo-rapidity ranges are $2.8 < \eta < 5.1$ (V0A) and $-3.7 < \eta < -1.7$ (V0C). The detector is used as a minimum bias trigger and for rejection of beam-gas background. A large background trigger rate is is expected in the muon spectrometer trigger chambers. The absence of a Minimum Bias Trigger (MB) from V0C alone, will be a good signal to reject a large part of thes false muon triggers [6].

SUMMARY

ALICE will participate in standard pp runs at reduced luminosity ($3 \times 10^{30}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$). Quartiary halo from the TCTs is a concern since it might represent the largest background source. At full intensity ALICE will run at $\beta* = 10\,\mathrm{m}$. ALICE requires that for stable beams the TCTs will be put at a position at which it protects the inner triplet against accidental losses but does not produce extra losses for stable beams. Special beam condtion detectors and ALICE forward detectors are used for background monitoring.

REFERENCES

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