Summary

This Technical Design Report describes the ALICE Transition Radiation Detector (TRD). This detector provides electron identification as well as triggering capability for high transverse momentum processes. In the following we briefly summarize the main design considerations and the proposed technical solutions.

Hard processes, and in particular studies of charm and beauty production in both the open and hidden charm sector have become center stage for the ALICE physics program. The TRD, in conjunction with the ITS and TPC, provides the relevant capability for the measurement of high p_t electrons. In addition, the TRD can be used to trigger on high p_t (> 3 GeV/c) particles, thus providing not only enriched samples for Υ production but also the capability to select jets. A survey of the physics capabilities and resulting design specifications is given in Chapter 1.

The design objectives and mechanical structure are presented in Chapter 2. An important issue in this context is the organization of the TRD chambers in supermodules and their support in the ALICE space frame.

The radiator structure and technical realization are discussed in Chapter 3. Based on the experience gained in a series of test beam measurements described in Chapter 14, a sandwich construction of foam and fibers was chosen. This not only yields the required amount of transition radiation but also provides the structural rigidity to support the front window of the readout chamber, at reasonable cost and small radiation length. The overall material budget is summarized in Chapter 10, and amounts to less than 14% of a radiation length for the active volume of the detector.

The 540 readout chambers contained in the full TRD are essentially radial drift chambers with conventional wire amplification and cathode pad readout. To ensure optimal absorption of transition radiation the chamber gas will be 85% Xe and 15% CO_2. The demands in terms of resolution and operational conditions are not very high for each chamber: typically a few hundred microns of spatial resolution are sufficient. Detailed chamber design and optimization is given in Chapter 4.

In Chapters 5, 6, and 7 are described the front-end electronics, trigger electronics and performance, and the readout and data flow for the full detector. With $1.16{\cdot}10^6$ channels a high degree of integration is required. To optimize the transition radiation performance and simultaneously to provide the necessary tracking capability the electronics chain is based on a charge sensitive pre-amplifier feeding signals into a sampling ADC integrated into a digital chip, where all the logic for the trigger resides. Design, prototyping, and expected performance of the front-end electronics are summarized in Chapter 5.

The trigger performance based on these electronics components is studied by detailed simulations and results are reported in Chapter 6. The simulations are based on measured test beam results and the detailed design of the trigger. The on-line tracking performance is near that of off-line tracking reported in Chapter 11 for low mulitplicity events, but deteriorates somewhat for very high multiplicity. Nevertheless, even for the highest conceivable multiplicity density of $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}y = 8000$, enhancement factors of about 20 are achieved for detection of Υ states in minimum bias Pb–Pb collisions.

For the readout and data flow one needs to consider two main data streams to be handled in real time. One stream concerns the raw data readout, while another is connected to the shipping of the information on the tracklet candidates produced in the global tracking unit of the trigger. The details of the design are discussed in Chapter 7.

Because the TRD uses the rather expensive xenon as the main chamber gas component in its approximately 27 m^3 volume, special requirements had to be put on the design and performance of the gas system, presented in Chapter 8. The system described there is based on a closed loop design, making use of components standardized for all LHC detector gas systems. The main components and functionality have been tested in a prototype gas system built for the detector test runs described in Chapter 14.

The total power necessary to run the full TRD electronics is about 68 kW (52 kW for Pb–Pb colli-

sions). This places strict requirements on the services for the TRD detector, especially concerning the low voltage power distribution. The resulting detailed design is presented in Chapter 9.

Chapter 11 is devoted to a description of the detector performance, with main emphasis on the dependence of pion rejection and tracking on the expected high multiplicity environment in Pb–Pb collisions at LHC energy. For the relevant momenta of 1 GeV/c and larger, the tracking efficiency is above 80% and only weakly dependent on event multiplicity. As expected, the pion rejection deteriorates with event multiplicity. However, at 90% electron efficiency we expect a pion rejection factor of about 50, for the highest conceivable multiplicity density of $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}y = 8000$.

In Chapter 12 are summarized the acceptances and resolutions expected for the TRD for different physics processes such as the measurement of open charm and beauty and of various quarkonia via their electron decay channels.

Detector control and safety are important issues for a detector as complex as the TRD and our proposed technical specifications and solutions are described in detail in Chapter 13.

All simulations described in this report are based on detailed test beam measurements performed with TRD prototype detectors. This has led to a wealth of results summarized in Chapter 14. The test beam results demonstrate both the required pion rejection and position resolution. Furthermore, the radiator and chamber design are based on the experience with the prototypes.

Careful attention to mass production is an obvious issue for a detector comprising 540 radiators and readout chambers with about 770 m^2 total area. The main requirements are collected in Chapter 15.

In Chapter 16 are described the plans for implementation, installation, and access and maintenance for the TRD detector. The planned supermodule structure as well as the decision to concentrate all services on the side of the baby space frame (opposite to the muon arm) will facilitate installation and access significantly.

Organizational aspects, budgets and schedules are presented in Chapter 17. The TRD group now comprises 5 major institutions with significant experience and manpower. The overall budget of 14.8 MCHF is in line with previous estimates. We note, however, that the baseline budget for the TRD as outlined in the ALICE MoU contains only about half of the amount needed to build the full detector. Possible strategies are briefly discussed.