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Upgrade of Projectile Spectator Detector at NA61/SHINE experiment

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The NA61/SHINE experiment [1] continues ion studies from it's predecessor – NA49 [2,3]. The main aim is to search for the critical point and studying in details the onset of deconfinement [4] by performing a two dimensional scan of the phase diagram (see Fig.1). This can be achieved by varying the energy (13*A* – 158*A* GeV) and size of the colliding systems (p+p, p+Pb, Be+Be, Ar+Sc, Xe+La and Pb+Pb). The planned physics program is shown in Fig.2. NA61/SHINE is situated on H2 beam line of SPS accelerator at CERN.

Schematic picture of detectors at the NA61/SHINE experiment are shown in Fig.2. Four time projection chambers (TPCs) are used to reconstruct tracks of particles produced in collisions. Particle identifications are performed with time-of-flight systems. New physics program of NA61/SHINE experiments beyond 2020 includes open charm measurements. Current beam rate has to be increased by an order of magnitude up to 10^6 ions/spill. This requires NA61/SHINE detectors upgrade. The upgrade includes new read-out electronics for TPC chambers, constructing of new forward TPCs, new beam positioning detectors BPDs and new time-of-flight chamber based on fast multiplate resistive time chambers (MRPC).

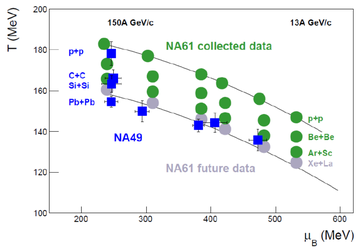


Fig.1 NA61/SHINE heavy ion studies

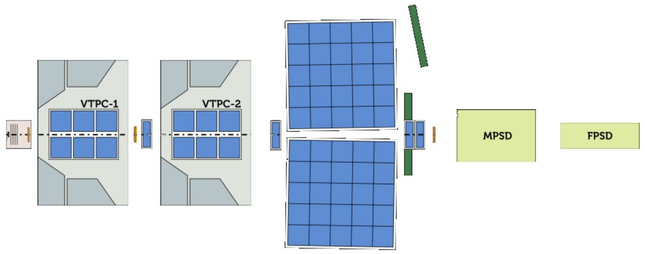


Fig.2 NA61/SHINE experiment setup upgrade

The Projectile Spectator Detector (PSD) [5,6] is a segmented forward hadron calorimeter used at NA61/SHINE to determine the collision centrality and the orientation of an event plane. A precise characterization of the event class is of crucial importance for selection of event centrality at the trigger level as well as for the analysis of event-by-event observables. It is is used also to study a collective flow.

Upgrade of NA61/SHINE and high expected beam rate requires PSD upgrade to survive in new high radiation conditions and to have faster read-out electronics. Instead of the present PSD, two forward calorimeters will be used (see Fig. 3). The first one (main PSD, MPSD) is modified current PSD with beam hole in the center and the second one (forward PSD, FPSD) is placed behind and is a new calorimeter with small transverse sizes placed downstream (see Fig. 4). The MPSD and the FPSD consist of modules with size 20x20cm2. Each module contains 60 layers of 16mm lead + 4 mm scintillator. Read-out is made with wavelenght shifting fibres (WLS) in groupes of 6 consequative scintillator plates (see Fig. 5 left). This gives a longitudinal segmentation with 10 sections in each module. The upgrade includes new fast Hamamatsu MPPCs used as a photosensors (see Fig. 5 right). The MPPCs have 90000 pixels which gives a large dynamic range of read-out signals. The pixel recovery time is about 10ns which cancel signals pile-ups. The new front-end-electronics (FEE) has been designed for FPSD and FEE for MPSD has been modified (see Fig. 6 left). New method to maintain MPPCs gain based on HV tuning according to temperature has been developed. The fast MPPCs requires new fast read-out electronics. During upgrade the new DRS4 based waveform read-out electronics has been constructed and successfully tested with MPSD and FPSD on cosmic moun calibrations. The data rate of DRS4 can survive up to 10kHz interaction rate. Number of channels is 32 per board. The DRS4 board is shown in Fig. 6 right.

Due to the beam hole in the center of MPSD the radiation damage is no longer a problem for main calorimeter andthe only center of FPSD will be irradiated (see Fig. 9). The central module of FPSD has a hole in the scintollator plates in order to avoide signal change during irradiation. The forward calorimeter performance is shown in Fig. 10 as a comparison of resolution in measuring collision centrality of old PSD and new MPSD + FPSD system. The performance will not changed after upgrade of calorimeters and for mid-central events the impact parameter resolution is around 10%.

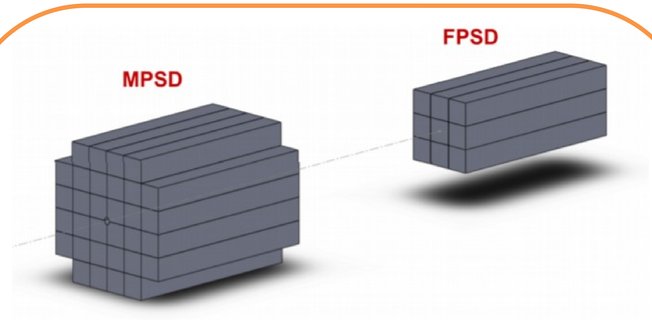
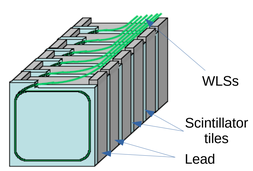
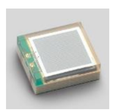


Fig. 3 New calorimeter system at NA61/SHINE (schematic view)

Fig. 4 New MPSD + FPSD calorimeter system at beam line





Hamamatsu S12572-010P

Fig. 5 PSD section schematic and MPPC used in lingrt readout.

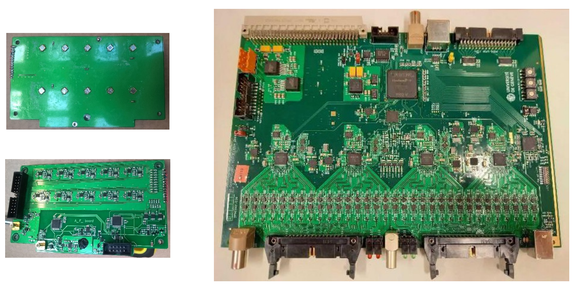
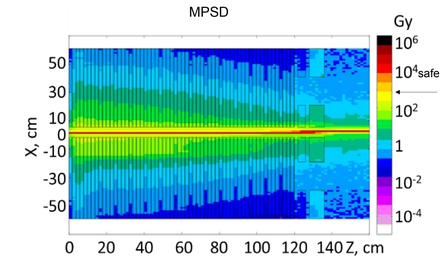


Fig. 6 FEE with new MPPCs (left) abd DRS4 read-out board (right).



Pb150 beam 2.5x10^4 1/sec (10^6 per spill), 1 month run

Fig. 7 Radiation level in MPSD + FPSD calorimeter system (FLUKA simulation).

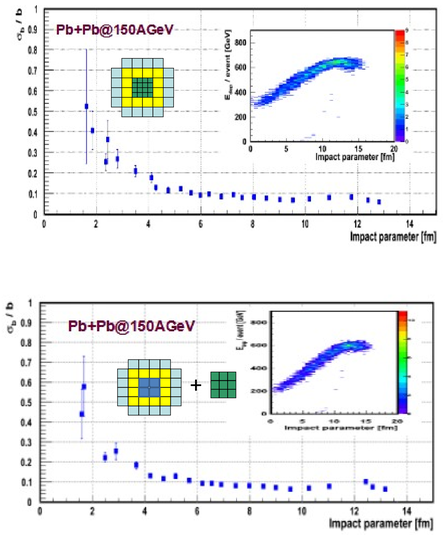


Fig. 8 Comparison of old and new PSD calorimeter's resolution of collision impact parameter.

References

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