Conceptual study of super-compact calorimeter design for the forward physics

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Abstract

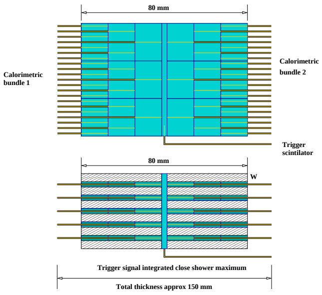
One of the long standing puzzles in the understanding of fundamental QCD is the production of particles in the forward direction. This kinematic region allows one to address very low Bjorken-x and consequently constrain the saturation scale that determines the suppression driven by coherence effects. It will also allow to greatly improve the precision of parton distributions in nuclei. The conceptual study of a super-compact electromagnetic calorimeter(ECAL) in the forward region is proposed. It is based on the tungsten - scintillator calorimetry that provides desired acceptance and due to its compactness also the possibility to include hadronic calorimeter(HCAL) part. This design enables to measure up to 200GeV photons, discriminate two photons from neutral pion decay and identify direct photons in wide energy range. Moreover, jet quenching measurements and jet calorimetry will be possible.

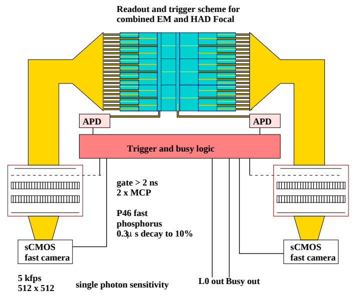
1 Motivation

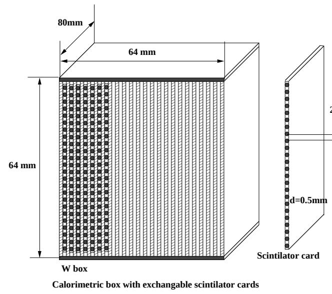
Particles produced in the forward direction originate dominantly from gluon interactions providing possibility to scan low x gluon densities. Furthermore, saturation effects can be studied by constraining suppression of particles produced in nuclear collisions. Basic measurements to study the physics aspects are forward π^0 and jet production, prompt photon production, quarkonia and leptons from heavy quarks, etc. The aim of our project is to develop new super-compact ECAL for the forward region based on the tungsten-scintillator calorimetry for wide pseudorapidity range for γ energies up to E $\sim$ 200GeV able to operate in high particle fluxes.

2 Design of the detector and simulations

The detector consists of sandwiches of tungsten plates and thin scintillator cards oriented in parallel to the beam. Scintillator cards consist of variable granularity pads with optical readout.

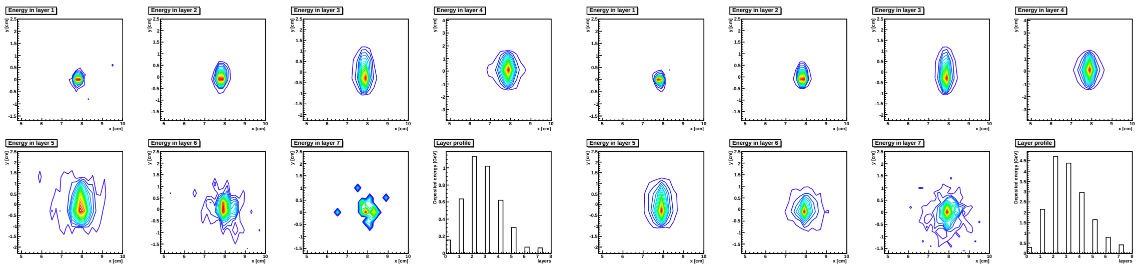






High quantum efficiency radiation hard inorganic scintillators (YAG, 3HF,. . .) are 0.5 mm thick. Due to variable granularity pad size the best resolution is in the first and last layer while in the middle the signal is integrated at shower maximum. Therefore it is possible to do simple tracking of hard particles. Noise and low energy particles are suppressed by triggering at shower maximum. High purity tungsten plates are 1.5mm thick. Optical readout is made of radiation hard quartz optical fibers from scintillators to an image intensifier and a high speed camera. Thanks to camera properties it is possible to achieve single photon sensitivity and 5kHz full frame operation. Moreover, fast shutter gate(<2ns) allows precise event selection(trigger) in time.

Response of the detector to 50GeV(left) and 200GeV(right) photons(signal reconstruction) up to rapidity 4.5 is presented here. It is clearly visible that precise reconstruction is possible due to different energy deposition in layers at different depths.



3 Summary and Conclusions

Concept of super-compact ECAL for forward rapidity region has been examined in this paper allowing for γ and π^0 identification up to 200 GeV. Because of the technologies and materials used, this detector can be used in strong radiation environment and EM fields do not affect its operation. Moreover, there is no need for cooling and power the detector. The prototype is being made for EM beam test.

This work was supported by grant MSMT LC07048.