Physics and Design Studies for a Silicon-Tungsten Calorimeter for the ALICE experiment at CERN

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Introduction

The Large Hadron Collider (LHC) at CERN is capable of delivering proton-proton (p+p), proton-ion (p+A) and ion-ion (A+A) colliding beams at highest energies possible so far. Although the ALICE experiment is designed for the high-energy, high-density matter for exploring Quark-Gluon Plasma, the experiment is capable of studying outstanding fundamental QCD problems at small Bjorken-*x* values. As one of the possible design for the up gradation of the experiment, we have studied a sampling type silicon-tungsten calorimeter, to be placed in the pseudo-rapidity region of 2.5 to 4.7 (~6cm to 60cm from beam axis). The calorimeter would be an excellent addition for studying basic QCD physics at very high LHC energies, such as:

- ✓ Investigation for nuclear parton distribution function (PDFs) at small-*x*.
- ✓ Test of pQCD (perturbative QCD) predictions
- ✓ Saturation of gluon-PDF: Linear QCD evolution would predict that an ever growing parton (specifically gluon) density at small-*x* or large energy which is in violation of unitarity. It is expected that nonlinear processes (e.g. recombination) will become important at sufficiently high gluon density (small-x) which may lead to saturation effect to gluon distribution.
- ✓ Apart from small-x physics other topics such as **elliptic flow, Jet quenching, long range correlations** etc. can be studied in much more greater perspective. For example, measurement of elliptic flow in the early stage needs the knowledge of initial distribution of partons. On the other hand long range correlations help characterizing the medium in heavy ion collisions e.g. ridge like structure which originates because of passage of hard partons through the medium or coupling of radiated gluons with longitudinal flow etc.

Increasing the beam energy as well as going to higher rapidity, one can achieve low Bjorken-x. For the highest LHC energy and forward rapidity of the calorimeter, it is possible to go down to Bjorken-x of 10^{-5}.

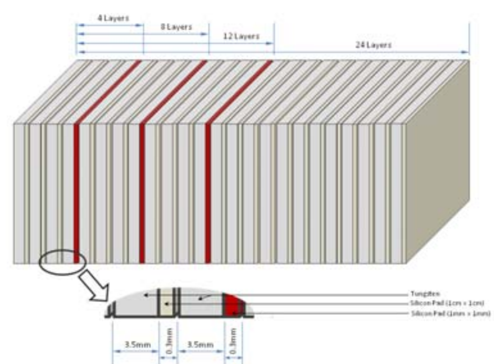

Fig-1: Sketch of the calorimeter with high resolution pixel layers shown in red.

Design of the Calorimeter:

For the sake of full containment of photon energy up to 200GeV the thickness of the calorimeter taken is 24 radiation lengths. For this purpose, a sampling type calorimeter (24 layers) with tungsten (absorber) and silicon (active material) has been considered. Two kinds of silicon detectors of sizes 1cm*1cm pad and 1mm*1mm pixel were used in the design. There are 3 pixel layers (4^{th}, 8^{th} and 12^{th}) which take care for good position resolution and tracking of incoming particles in high multiplicity density environment. Other active layers are composed of silicon pads. Particle density as a function of rapidity and distance from the beam axis for relativistic heavy ion collisions had been studied for p+p, p+Pb, Pb+p, and Pb+Pb collisions.

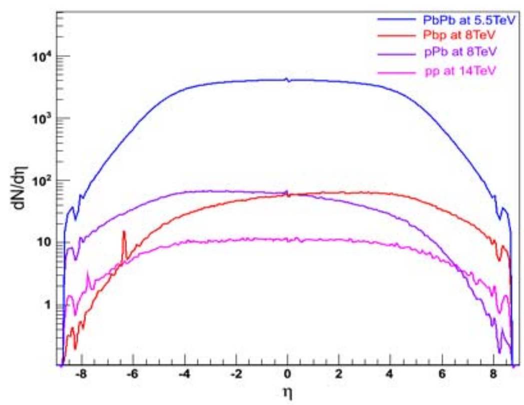

Fig-2 : Particle (photon) density as a function of Pseudorapidity using HIJING event generator at 350 cm away from the Interaction point.

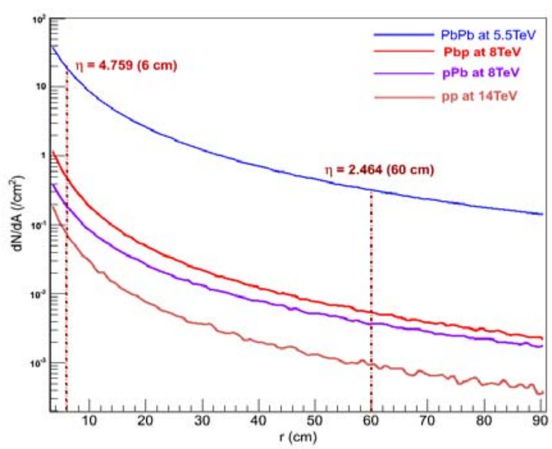

Fig-3 : Particle (photon) density as a function of distance from the beam axis using HIJING event generator.

From areal density *vs.* radial distance (Fig-3) it has been found that maximum 14 particles per cm^2 will fall on the innermost side of proposed calorimeter region for Pb+Pb case. As with electromagnetic calorimeter, measurements are done through reconstruction of clusters produced by electrons and photons, the occupancy will be large for Pb+Pb collisions. So the detector needs to be optimized for Pb+Pb collisions so that it works well for p+p and p+Pb collisions.

We had studied reconstructions of clusters using fuzzy logic for neutral pions decaying to two photons. It has been found from our study that two overlapping clusters with centre-to-centre distance 3 mm can be resolved with this technique. As theoretically minimum distance between two decayed photons from 200 GeV π^0 at 350 cm away is about 1 cm, the proposed calorimeter is expected to work safely for π^0 energy range 1 to 200 GeV.

Presently effect of front side material to the calorimeter data is being studied. Details of designs, technological issues and data reconstruction is intended to be presented.

References:

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