γ-jet physics with EMCal at ALICE experiment.

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Les γ-jets sont des événements rares où un photon et un hadron sont créés par effet Compton ou annihilation. Le parton s'hadronise et forme une gerbe de particules appelée jet. Le photon et le jet sont émis dos-à-dos, on parle de γ-jet. L'intérêt des jets n'est plus à démonte depuis RHIC qui l'a prouvé par l'observation de la suppression des hadrons de haute impulsion transverse (phénomène de « jet quenching »). Cette perte d'énergie, ou plus exactement la redistribution de l'énergie dans le jet, peut être mise en évidence par la modification de la distribution de l'énergie des particules appartenant au jet en collisions p-p et Pb-Pb (hump-backed plateau). Cette mesure nécessite de déterminer l'énergie initiale du jet, ce que les γ-jets permettent de faire de façon élégante et précise.

Comparing jets in Pb-Pb and p-p collisions will show the energy redistribution in the jet : due to strong interactions in quark and gluon plasma (QGP), high momentum particles radiate gluons, which leads to a decrease of high momentum particles and an enhancement of low momentum particles. This phenomenon is called "jet quenching" [2].

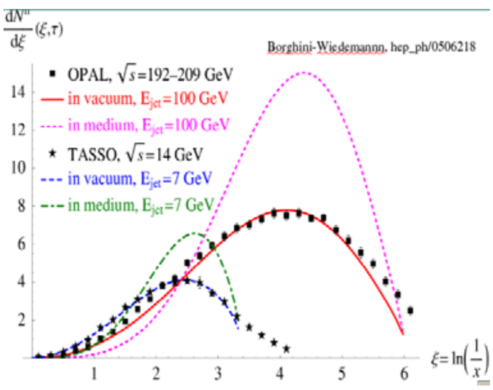

Fig. 1: Theoretical modification of the hump-backed plateau due to jet quenching in dense medium (dashed lines) and hump-backed plateau without quenching effect (solid lines). compared to experimental points (symbols) [3].

The hump-backed plateau [3] is an interesting observable to explore the modification in jet energy distribution induced by jet quenching. It is represented by the $\xi = \ln(1/x)$ distribution, where x is defined as $x = p_T(\text{hadron})/p_T(\text{jet})$ for the jet particles. Its modification due to the medium is a promising observable for QGP study. Fig 1. shows this experimental distributions, th so-called hump-backed plateau from different experiences[3] and a theoretical modifications due to a QGP.

Year 2008 will see the first LHC[1] runs. For the 2010 Pb-Pb run, the EMCal[2] will be partially installed and operational. This calorimeter will be dedicated to neutral particles detection in ALICE and will provide the opportunity to study γ-jet physics. EMCal will be used for the gamma reconstruction and the central tracking (ITS[3] and TPC[4]) for jet reconstruction. γ-jets are essential to assess the jet energy loss in a QGP by providing a jet energy calibration. Since photons penetrate the dense medium with greatly reduced interactions compared to hadrons, it provides an excellent measure of the energy and direction of the tagged jet.

The detectors and available beam energy at RHIC[5] are not fully satisfactory for gamma-jet studies : due to the large amount of underlying background and limited acceptance, it is very difficult to identify both direct photon and tagged jet. The gamma-jet cross-section is small at RHIC, their detection and analysis is still very hard [6]. This study will be possible at LHC energies. In ALICE experiment, the predicted rate for γ-jets with an energy >30 GeV is about 10000 events per year (considering the gamma in EMCal). This energy is the limit to be able to distinguish jets from the background.

[1] Large Hadron Collider.
[2] Electro Magnetic CALorimeter
[3] Inner Tracking System
[4] Time Projection Chamber
[5] Relativistic Heavy Ion Collider.

EMCal offers the possibility to detect gammas over wide energy range up to 100 GeV, with a resolution lower than 3% for energy > 30 GeV. It also gives the possibility to identify photons by shower shape analysis with an efficiency more than 60% and a purity > 70% for $15<p_T(\gamma)<50$ GeV [4].

The tracking system can reconstruct tracks from charged particles from 100 MeV to 100 GeV with a resolution about 2% [1]. Combined with an efficient “UA1 like” cone algorithm, it is possible to reconstruct jets at the opposite of the gamma with an efficiency about 60% [4]. Previous reconstruction of the gamma reduces the searching area for the jet to a tin azimuthally ($|\Delta\phi|<0.5$) opposed strip and gives directly the energy of the jet.

Fig 2 shows the hump-backed plateau from simulated γ-jets and reconstructed in the ALICE environment, The background is not simulated her. For this study, 100 GeV gamma-jets were simulated using PYTHIA [5] Monte Carlo. Two samples of events were simulated : one with and on without quenching effect. The modification of the hump-backed plateau (Fig 2.), due to quenching effect, is viewable by an enhancement of high ξ particles and a suppression of low ξ particles. This modification can be used to measure the quenching effect.

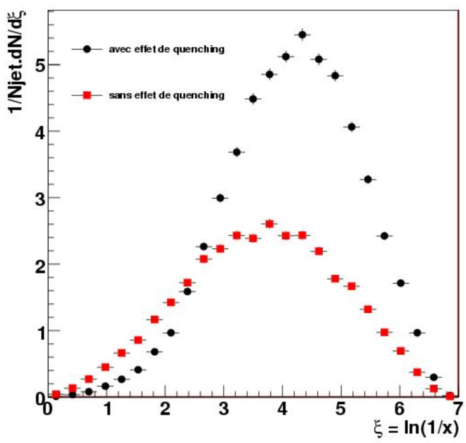

Fig. 2: Simulated modification of the hump-backed plateau due to jet quenching in dense medium in ALICE with full reconstruction.

The QGP is supposed to be formed in heavy ion collisions. In such collisions, jets are polluted by low p_T particles background. This background is the main difficulty to obtain the hump-backed plateau for high ξ. A third sample of γ-jets events has been simulated, merged with underlying heavy ion collisions events to simulate Pb-Pb events with background.

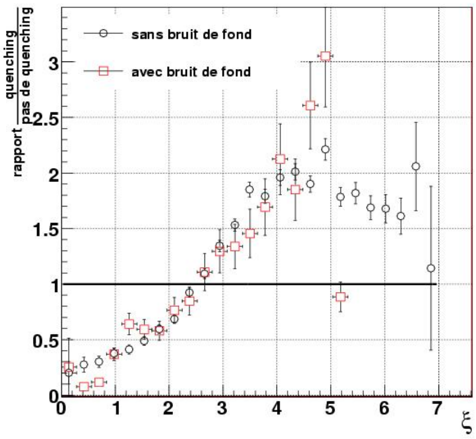

Fig. 3: Measured ratio of hump-backed plateau with and without underlying events.

The ratio for the hump-backed plateau is presented on Fig 3. The modification is not biased by underlying event for ξ between 1.5 and 4.

These results show that the ALICE experiment with the EMCal will be a well suited tool for γ-jet study and jet fragmentation : the hump-backed plateau can be measured and its modification between p-p and Pb-Pb collisions can be used to measure quenching effect.

La Physique des γ-jets permet de sonder efficacement le plasma de quarks et de gluons : le photon n’ayant pas d’interaction avec le milieu, il peut servir de référence pour détecter et étudier le jet émis à l’opposé.
Les caractéristiques de ce jet, comme la distribution de l’énergie des particules dans celui-ci sont fortement liées au milieu traversé par la particule à l’origine de ce jet.
Pour cette étude ALICE et son calorimètre de grande acceptance EMCal sont au LHC un outil performant, permettant une étude des γ-jets jusqu’alors impossible. Cette observable permettra de sonder la plasma de quarks et de gluons et d’étudier plus en avant les propriétés de cet état de la matière.

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