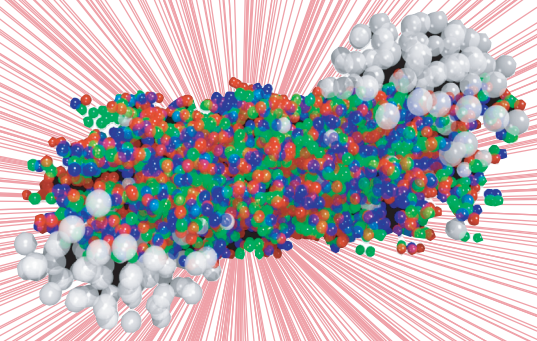
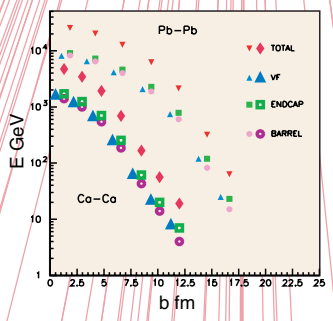
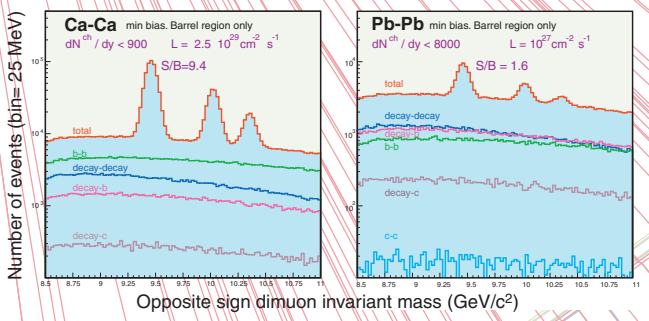
Heavy Ions



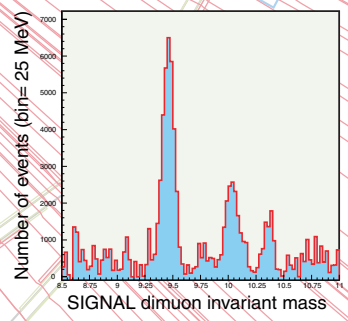
The LHC will not only collide proton beams: some periods of time will be spent colliding beams of nuclei, such as calcium (Ca) and lead (Pb). Collisions between these nuclei will produce “little bangs” at a temperature of ~ 200 MeV (around 100,000 times that of the centre of the sun), and an energy density up to 30 GeV/fm^3 (200 times that of normal nuclear matter). Under these extreme conditions, which mimic those of the very early Universe ~ 10 μs after the Big Bang, the constituent protons, neutrons and gluons (the carriers of the inter-quark force) “melt” to form a “quark-gluon plasma (QGP)”. CMS is very well suited to study some aspects of the formation of the QGP through the detection of muons and jets



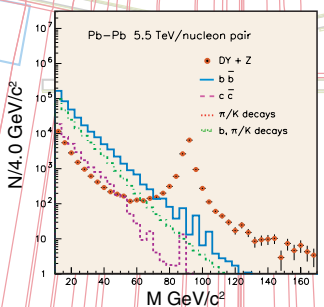
We can differentiate peripheral events, which have no plasma formation, from central events, where the QGP is expected, by measuring the impact parameter of the collision. The impact parameter of the nucleus-nucleus collision will be given by the transverse energy flow measured in CMS calorimetry (electromagnetic and hadronic) over a wide rapidity range, up to |η|=5



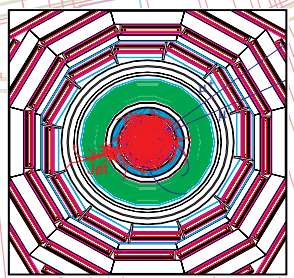
One of the best signatures proposed as evidence for quark-gluon plasma formation is the suppression of heavy quark vector mesons due to colour screening. CMS is particularly well suited to study this suppresion within the Υ family and to a lesser extent for the J/ψ and ψ' through their dimuon decay channel.The main background comes from the uncorrelated π/K decays and b production.The spectra are estimated for 1 month (1.2×10^{6}s), without suppression, and for muons reconstructed in the |η|<1.3 region where a reconstruction algorithm based on a (δφ, P_T) roads technique has been developed. A reconstruction efficiency plateau at 92% extends up to dN$^{\pm}$ /dη=2000 and decreases to 64% for dN$^{\pm}$/dη=8000. The resolution at the Υ mass (the peak at 9.46 GeV) is 50 MeV.



Opposite sign dimuon invariant mass spectrum for Pb-Pb events after subtracting the uncorrelated background from like-sign dimuon events



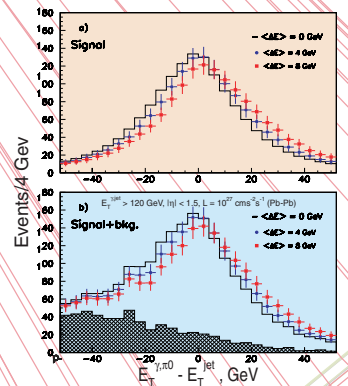
Detection of the $Z \rightarrow \mu^+\mu^-$ will provide a good reference point as the point-like Z-boson is not expected to be affected by the plasma. The different sources of background are shown for muons with P_T>5 GeV/c detected in the CMS barrel region



Z+jet event in the Heavy Ion collision

Z ($\rightarrow \mu^+\mu^-$)+ jet event with P_T^Z=100 GeV in a Pb-Pb collision in CMS. Charged particles with a multiplicity density dN^{ch}/dy=5000 are drawn in the slice Δη=0.1 around one of muons from the Z decay. Such events could be used to investigate jet quenching as P_T^Z is known from $Z \rightarrow \mu^+\mu^-$. For a one month run (1.2×10^{6}s) we expect 600 Z ($\rightarrow \mu^+\mu^-$) +jet events with E_T^{jet}>50 GeV in |η|<1.5

Hard jet production is another possible probe to study the formation of the QGP. Energy loss of the gluon (quark) in traversing dense matter leads to “quenching”, i.e. the suppression of high P_T jets. Di-jet quenching, the enhancement of the monojet/dijet ratio and the study of jets in Z+jet and γ+jet channels are possible probes. Modified WINDOW and cone type algorithms have been developed for extraction of high-P_T jets from the heavy ion background. The highest-E_T jet yield and the possibility to diminish the number of false jets depend on the chosen radius (R). The best performance is obtained for R=0.3 - 0.5



The $E_T^{\gamma/\pi 0}$-E_T^{jet} distribution for different jet energy losses is estimated for one month run (1.2x10^6 s) for barrel calorimeters (|η|<1.5). The main background sources are jet+jet events where one of the jets has a leading π^0