Contribution of HMPID detector to high-p_T physics at LHC

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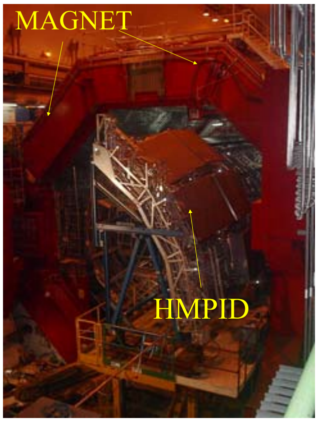
[a,b]D. Di Bari, [a,b]A. Mastroserio, [b,c]L. Molnar, [b]E. Nappi, [a,b]D. Perrino, [b]G. Volpe.

[a]Dipartimento Interateneo di Fisica "M. Merlin", Bari, Italy.

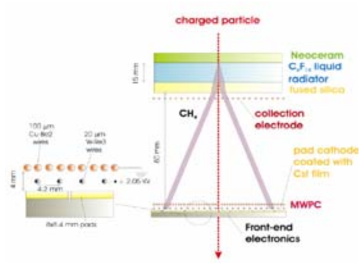
[b]Istituto Nazionale di Fisica Nucleare, Sezione di Bari, Italy.

[c]Research Institute for Particle and Nuclear Physics (KFKI-RMKI), Budapest, Hungary.

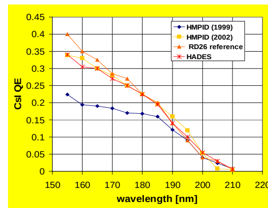
The LHC will deliver unexplored energy regimes for proton-proton and heavy-ion collisions. As shown by the RHIC experiments particle identification over a large momentum range is essential to disentangle physics processes, especially in the intermediate p_T region ($1 < p_T < 5$ GeV/c). The novel design of the High-Momentum Particle Identification Detector (HMPID), based on large surface CsI photocathodes, is able to identify $\pi^\pm$, $K^\pm$, $p^\pm$ in the momentum region where bulk medium properties and hard scatterings interplay. Furthermore, measurement of resonance particles such as the $\phi(1020) \rightarrow K^+K^-$, could provide information on the system evolution. The HMPID layout and segmentation is optimized also to study particle correlations at high momenta describing the early phase and the dynamical evolution of the collisions. At LHC the increased hard cross section will significantly be enhanced compared to RHIC. Identified leading particle correlations and jet reconstruction via Deterministic Annealing can address detailed measurement of jet properties. Here, we present these selected topics of the possible HMPID contributions to the physics goals of LHC.



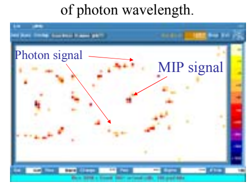
Installation of the HMPID in the ALICE magnet



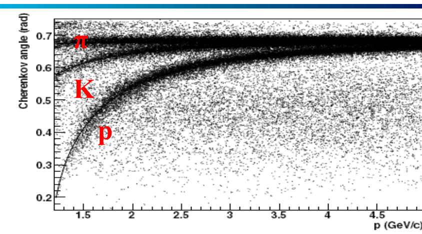
HMPID exploits the properties of Cherenkov light and large surface CsI photocathodes to identify charged particles on track by track basis. Charged particles crossing the detector produce Cherenkov photons in the radiator. These photons, detected by a pad-segmented cathode MWPC, produce a typical ring pattern. A dedicated algorithm of pattern recognition gives the information on the mean Cherenkov photon emission angle. Then PID could be performed.

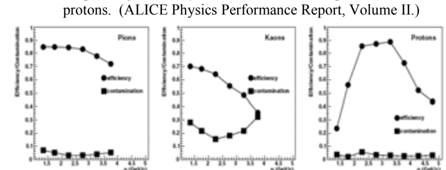


CsI quantum efficiency as a function of photon wavelength.



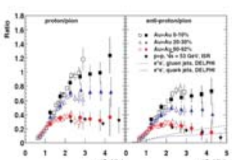
A display of rings from pions during test beam.





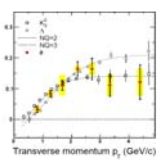
Particle identification in HMPID (upper panel) and the corresponding efficiency and contamination for pions, kaons and protons. (ALICE Physics Performance Report, Volume II.)

Single particle spectra and Φ(1020)



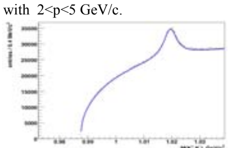
The p/π ratio is about one in most central collisions at $p_T > 2$ GeV/c (Phys.Rev.Lett. 91, 172301 (2003)).

The signals of the Quark Gluon Plasma are influenced by the mechanisms involved at the hadronization stage. At RHIC energies, in the momentum region: 2 – 5 GeV/c, hadron production may be driven by quark content dependent mechanisms. The baryon over meson ratio reaches unity in most central collisions; the elliptic flow scales with the hadron quark content.

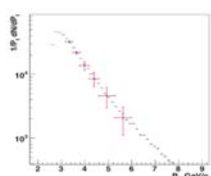


The elliptic flow of Φ(1020) follows the behavior of the mesons above $p_T \sim 2$ GeV/c. (nucl-ex/0703033v1).

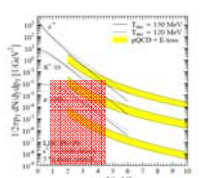
The Φ(1020) meson is a good probe to disentangle mass scaling from quark content scaling at the hadronization stage for three main reasons: its lifetime (~ 44 fm/c), its small cross section for scattering with non-strange hadrons and its mass which is very close to the proton. The comparison between the Φ(1020) and the proton production in the widest momentum range can provide new insights in the mechanisms involved at the hadronization stage. The identification of charged kaons in the momentum region 1 – 3 GeV/c by HMPID can contribute to identify both Φs and protons with 2<p<5 GeV/c.



Invariant mass of the Φ(1020) →K^+K^- in central Pb-Pb collisions (Hijing events in AliRoot environment). Kaons are identified by HMPID between 1.3 – 3 GeV/c. The mass resolution is 1.2 MeV/c².

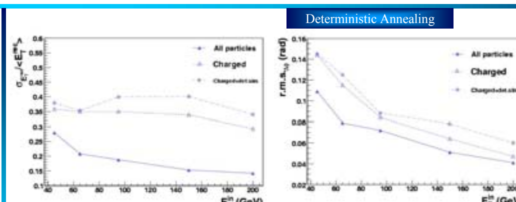


Reconstructed momentum spectrum of the Φ(1020) in six different momentum bins.

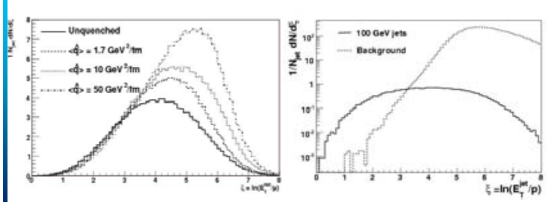


Charged hadron identification by the HMPID, especially for protons, will provide new insights in the QGP. (Phys. Rev. C 72: 044904, 2005)

Deterministic Annealing



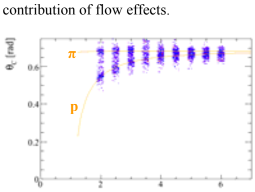
At LHC the 98% of total cross section will be represented by hard processes. For this reason jets production will be very copious and jets studies will be suitable to probe the hot and dense matter that will be formed in heavy-ions collisions and a new algorithm, Deterministic Annealing (DA), has been recently developed for jet finding in ALICE. Results from the DA algorithm are shown in the plots above, obtained from simulated PYTHIA jet events embedded into Pb-Pb HIJING events. The transverse energy and the direction resolution of the reconstructed jets as a function of E_T^{in} are referred to a monochromatic input spectrum of jets reconstructed with the same algorithm in a background free environment.



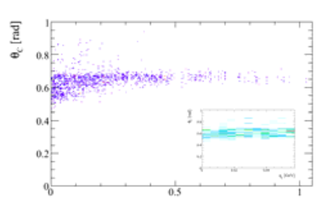
HMPID will contribute to the study of jet properties. In fact, the influence of medium on parton propagation after the hard scattering can be studied comparing the leading particle fragmentation between p-p and Pb-Pb collisions. In particular, in the plot below (Left panel: ALICE Collaboration *et al* 2006 *J. Phys. G: Nucl. Part. Phys.* **32** 1295-2040) the influence of different values of transport coefficient are shown through PYTHIA simulation. In the right panel the fragmentation of jets found with Deterministic Annealing is compared to background coming from Pb-Pb collisions. As a practical example, for 100 GeV jets $\xi \sim 3.5$ corresponds to $p \sim 3$ GeV/c.

HMPID HBT study

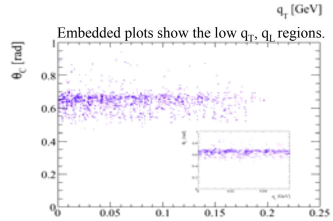
This final-state information of heavy-ion collisions is most directly accessed by interferometric methods, such as the Hanbury-Brown and Twiss (HBT) measurement. At LHC, due to the high multiplicity, event-by-event HBT measurements could be possible. The event-by-event HBT measurement requires 3σ separation in particle identification. The HMPID can contribute in the high–p_T region: to $\pi^\pm\pi^\pm$, $K^\pm K^\pm$ and $p^\pm p^\pm$ HBT measurements. Furthermore, non-identical correlations, such as $p^\pm - \Lambda$ could be performed to investigate the contribution of flow effects.

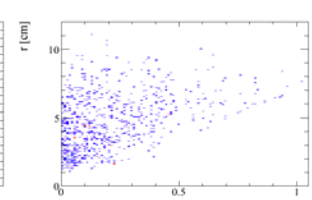


A preliminary study on the HMPID detector resolution of two close tracks addresses the capabilities of HMPID for HBT. Fast MC simulations of tracks in a close phase space (in different momentum bins) are performed, including complete simulation of HMPID response in a 0.2T magnetic field. The studied momentum regions are shown with the extracted θ_C for particle identification.

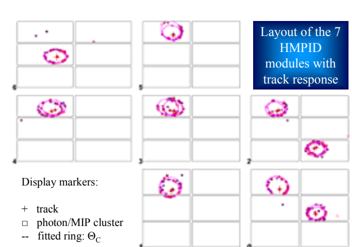


Embedded plots show the low q_T, q_L regions.





θ_C and distance of MIPS (tracks) as a function of Kopylov variables are shown.



HMPID is able to perform pattern recognition of two close tracks / rings at MIP separation of ~ 1 cm. (Pad size is 0.8 cm x 0.84.cm)

Resolution down to 10 – 50 MeV/c is achievable for q_T and q_L.

Improvements on pattern recognition will enhance the separation power for identical and non-identical HBT measurements.

For further information please visit the HMPID web sites:

http://alice-hmpid.web.cern.ch/alice-hmpid

http://richpc1.ba.infn.it