Particle identification techniques for measuring the hadron composition in charged jets from pp collisions with the ALICE experiment

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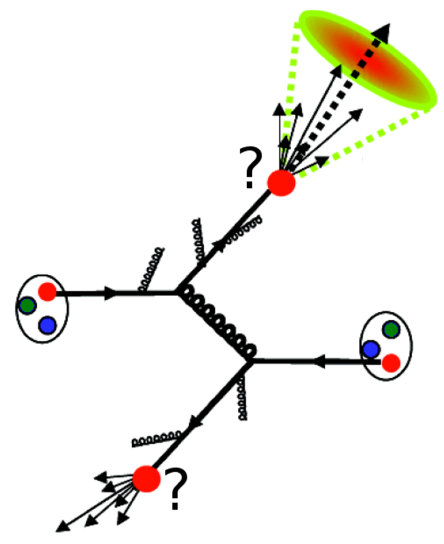
Introduction

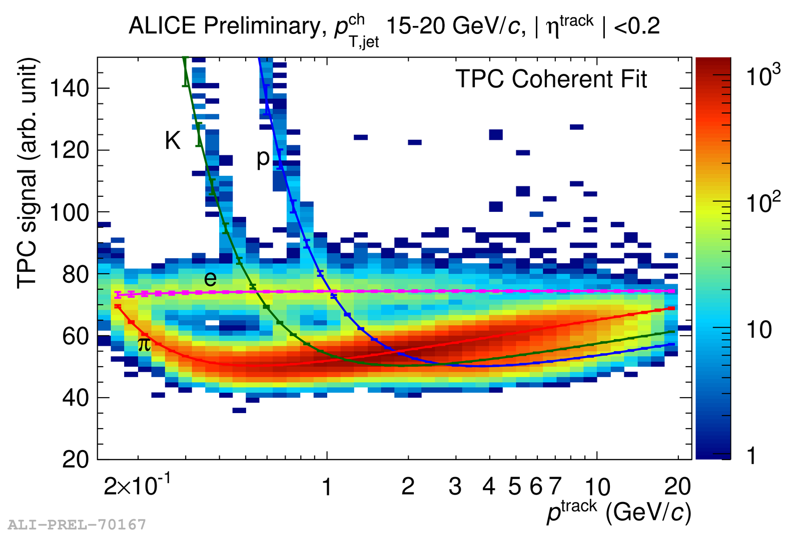


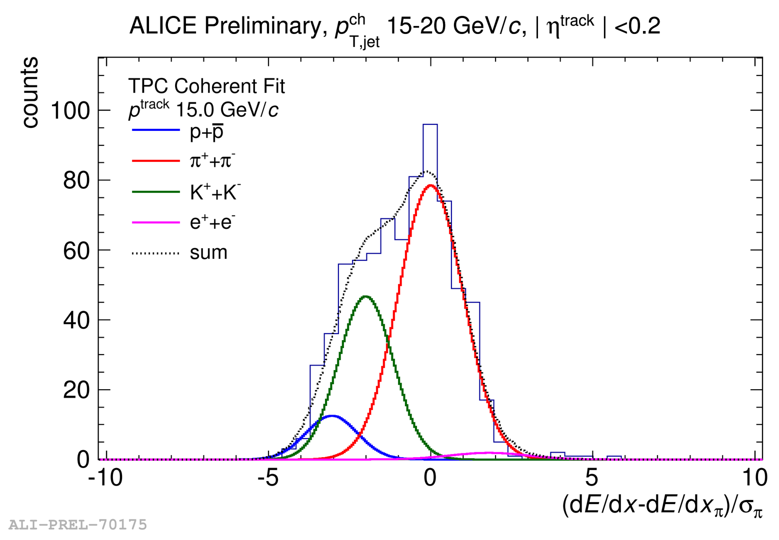
Jets are collimated bunches of particles. They originate from an initial hard QCD scattering followed by consecutive parton emission. The process of parton showering and subsequent hadronisation is broadly known as fragmentation. It can be accessed experimentally via jets. In particular, identified hadrons in the final state provide an enhanced sensitivity to the flavour dependence of fragmentation.

The ALICE detector at the LHC has excellent tracking and particle identification capabilities. Charged pions, kaons and (anti-)protons with transverse momenta (p_{T}) from 150 MeV/c up to about 40 GeV/c can be identified using the specific energy loss ($\mathrm{d}E/\mathrm{d}x$) in the time projection chamber (TPC).

We present the first measurement of particle type dependent jet fragmentation at hadron colliders. Two independent analysis methods have been developed for this purpose: the TPC Coherent Fit and the TPC Multi-Template Fit. On this poster, we show results for charged jets at mid-rapidity in pp collisions at $\sqrt{s} = 7$ TeV.

TPC Coherent Fit



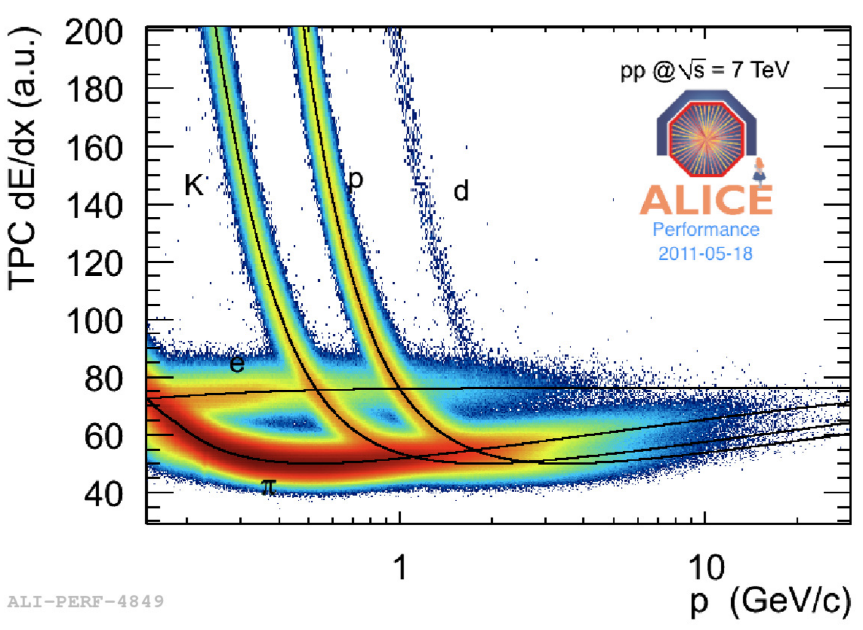


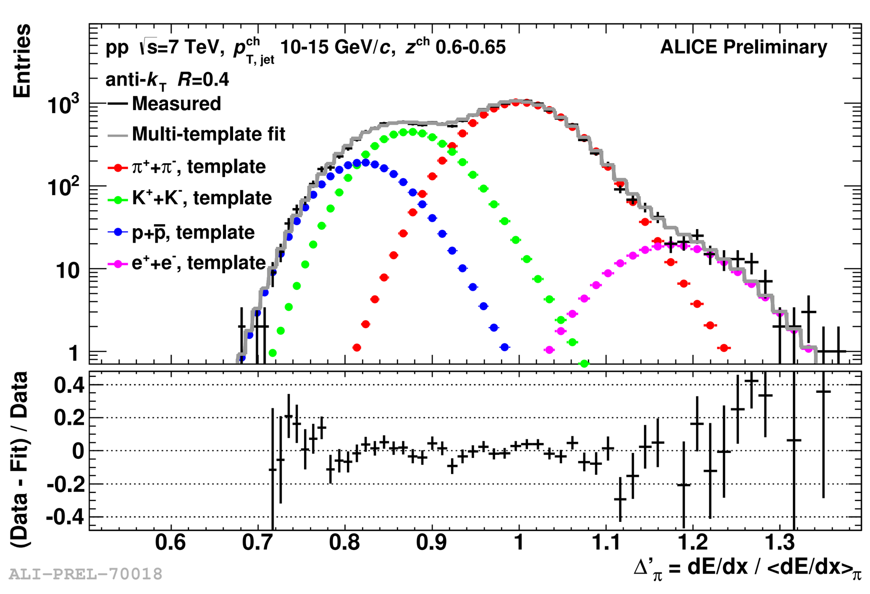
The TPC Coherent Fit extracts the particle composition for a given track sample by fitting both TPC $\mathrm{d}E/\mathrm{d}x$ model parameters and particle content at the same time ("coherence") to data.

This constrains the model parameters in the full momentum range (left figure). The fit is a binned log-likelihood fit with a regularisation term that suppresses deviations of the particle fractions from neighbour interpolation that are larger than statistical fluctuations. The fitting is performed as a function of p in small pseudorapidity (η) windows (right figure).

The weighted mean is used to convert the result to a function of $p_{\mathrm{T}}^{\mathrm{track}}$ or $z^{\mathrm{ch}} \equiv p_{\mathrm{T}}^{\mathrm{track}}/p_{\mathrm{T,jet}}^{\mathrm{ch}}$ ($p_{\mathrm{T,jet}}^{\mathrm{ch}}$ being the transverse momentum of a charged jet) and to combine the results of all η windows.

TPC Multi-Template Fit





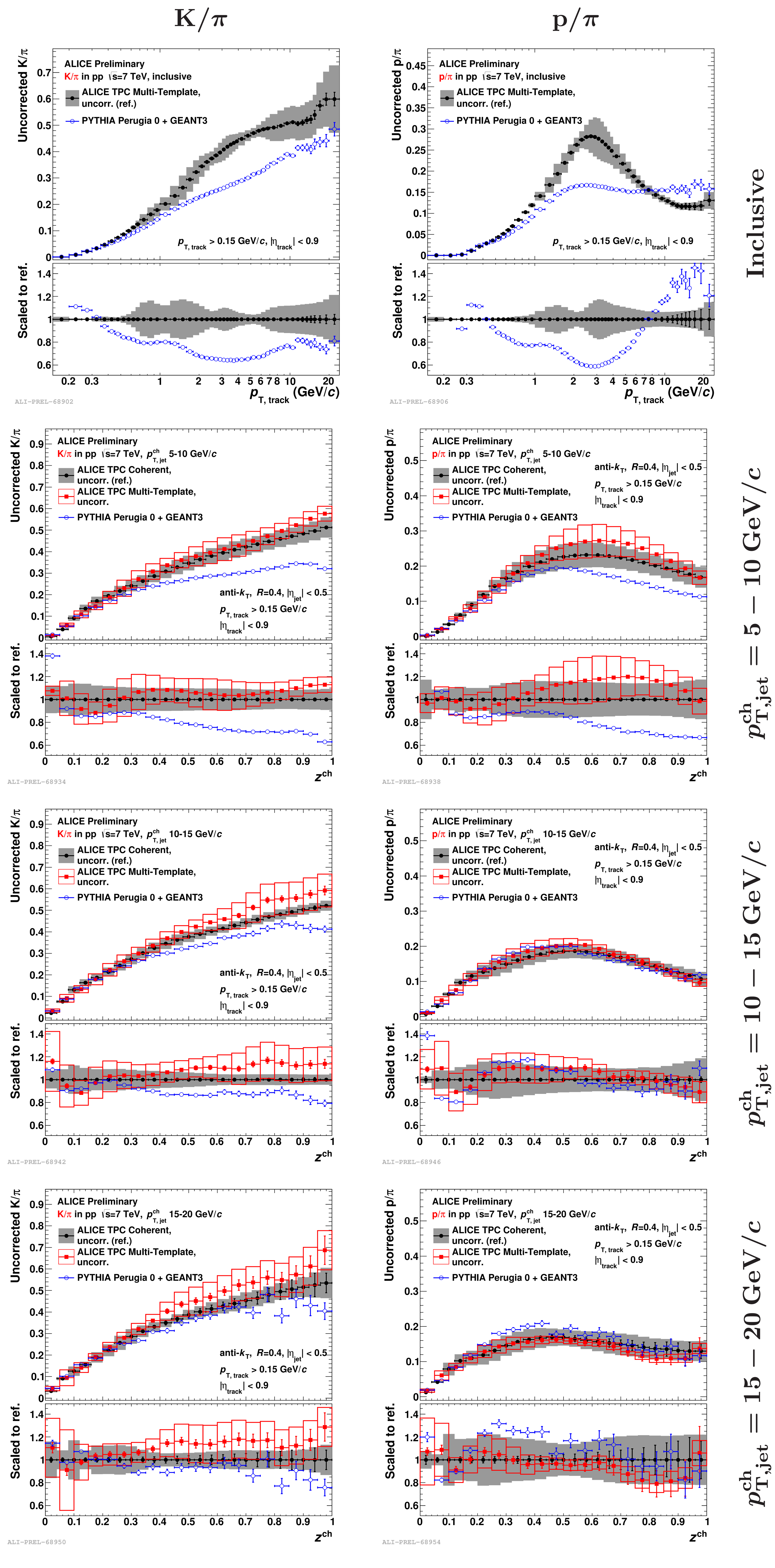
The TPC Multi-Template Fit models the TPC $\mathrm{d}E/\mathrm{d}x$ response in detail.

Pure track samples are selected based on TPC $\mathrm{d}E/\mathrm{d}x$, time of flight (TOF) and track topologies (K_S^0/Λ decays, photon conversions). They are used to extract the dependence of $\mathrm{d}E/\mathrm{d}x$ on $\beta\gamma$, polar angle, $\mathrm{N}_{\mathrm{clusters}}^{\mathrm{PID}}$ (number of clusters of the track used to calculate its $\mathrm{d}E/\mathrm{d}x$), $\cdots$.

This information is used to generate templates with the expected $\mathrm{d}E/\mathrm{d}x$ response for each species for the given track sample. The template generation can directly be carried out in bins of z^{ch} or $p_{\mathrm{T}}^{\mathrm{track}}$ and in the full acceptance $|\eta| < 0.9$. To extract the particle fractions, the difference between the measured $\mathrm{d}E/\mathrm{d}x$ distribution and template sum weighted by the species fractions is minimized in a binned log-likelihood fit. Like for the Coherent Fit, a regularisation term is included.

As shown in the right figure, the templates give an excellent description of data over 2-3 orders of magnitude.

Results



Charged jets are reconstructed via the anti-k_{T} algorithm with resolution parameter $R = 0.4$. The hadron composition of these jets is extracted with the TPC Coherent Fit and the TPC Multi-Template Fit.

The uncorrected K/π (left figure column) and p/π ratios (right figure column) are in agreement for both methods in all $p_{\mathrm{T,jet}}^{\mathrm{ch}}$ bins (figure rows).

The discriminating power of the extraction methods is demonstrated by comparing to the MC prediction from PYTHIA Perugia-0 propagated through a full detector simulation with GEANT3.

For $p_{\mathrm{T,jet}}^{\mathrm{ch}} = 5 - 10$ GeV/c, the MC prediction differs by up to 40% from the measurement, which is beyond the systematic uncertainties. We observe a similar discrepancy for the inclusive case, which is shown for reference in the first row. For higher $p_{\mathrm{T,jet}}^{\mathrm{ch}}$, we observe better consistency between MC and data.

As an outlook, the comparison to other MC models and different settings for the generators will allow to distinguish between fragmentation models and to constrain their parameters.