Spectra of weakly decaying identified particles at 0.9 and 7 TeV with the CMS detector

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Introduction: Measurements of particle yields and spectra are an essential first step in understanding proton-proton collisions at the LHC. The CMS Collaboration has recently published results on particle spectra of charged particles at 0.9, 2.36 and 7 TeV center-of-mass energies [1, 2]. The results presented here are repetition of the analysis for strange mesons and baryons (K^0_S, Λ, $\overline{\Lambda}$, $\Xi^{\pm}$) [3]. These measurements provide a testing ground for the interplay of soft and hard QCD interactions at the LHC, for the universality of fragmentation models and for the baryon transport mechanism. They also provide valuable information for the tuning of the Monte Carlo models and are an important tool for the calibration and understanding of the tracking system.

Reconstruction of strange particles: Candidates for long-lived strange neutral particles, were identified by selecting pairs of oppositely charged tracks, fitted to a displaced secondary vertex. The selection criteria were chosen after detailed studies of track and vertex reconstruction optimizing for high efficiency and purity. Cuts on track quality, primary vertex incompatibility, primary and secondary vertex separation, backpointing of the momentum of the mother particle were imposed among other conditions to clean the candidates [3]. The used decay channels for K^0_S, Λ and Ξ^- are the following: $K^0_S \to \pi^+\pi^-$, $\Lambda \to p\pi^-$ and $\Xi^- \to \Lambda\pi^-$, respectively (Fig. 1).

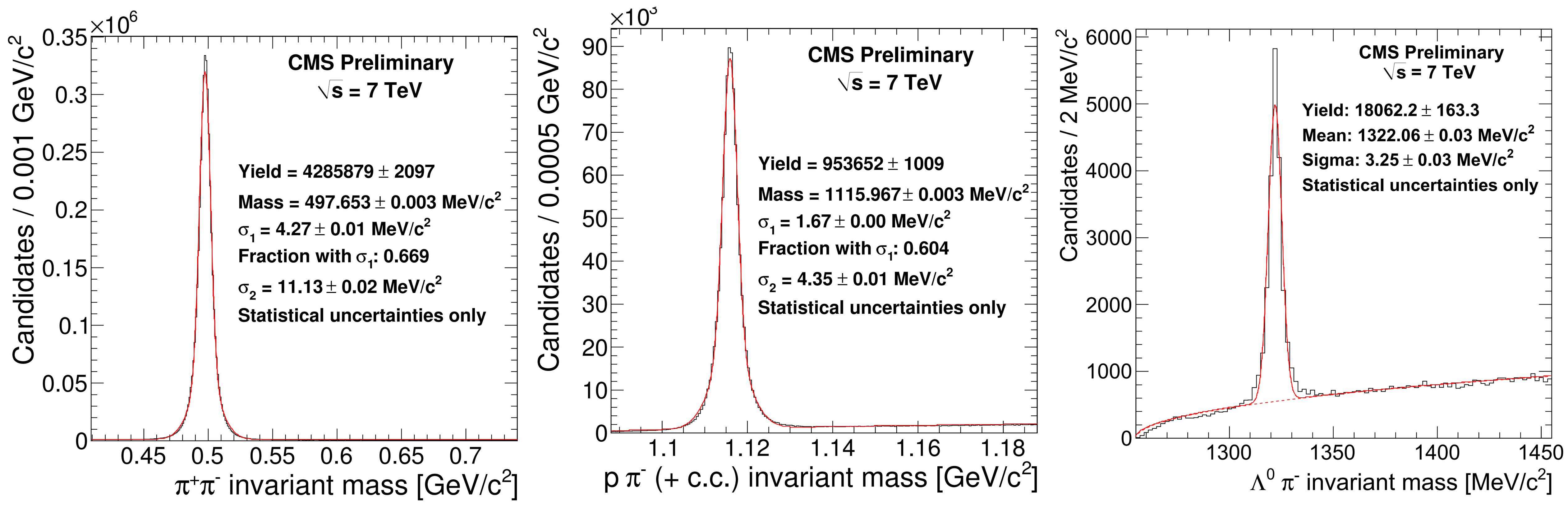

Fig. 1: The $\pi^+\pi^-$, $p\pi^-$(+c.c.) and $\Lambda\pi^-$(+c.c.) invariant mass for the data at c.m. energy of 7 TeV. The numbers in the legend report only the statistical error. The mass fits: a) K^0_S: sum of a double Gaussian for the signal and a second-order polynomial function for the background; b) Λ: same function for the signal and a function of the form $Aq^Be^{Cq+Dq^2}$, where $q=m_\Lambda-(m_p+m_\pi)$, for the combinatorial background; c) Ξ: a single Gaussian function for the signal, and an exponential of the form Ae^{Bq}, with $q=m_\Xi-(m_\Lambda+m_\pi)$, for the combinatorial background.

Triggering: A detailed description of the CMS detector can be found in [4]. The events were selected online requiring activity in the beam scintillator counters (BSC, $3.23 < |\eta| < 4.65$), coinciding with colliding proton bunches. The offline selection required in addition deposits in each forward calorimeter (HF) and a primary vertex. Additional beam halo and beam background rejections were also performed.

Corrections: The results are presented in terms of the transverse momentum, p_T, and the rapidity, y. For each distribution, the signal was extracted using the mass peak fit in each bin of that variable. A corrected yield was calculated, taking into account the trigger, selection and reconstruction efficiency, including acceptance effects, and the branching ratio. For the correction factors, the MC simulations with PYTHIA 8 (K^0_S and Λ) and PYTHIA 6 with the D6T tune (Ξ^-) were used. The non-prompt Λ production was increased by a factor of two in the MC, in order to match the observed Λ and Ξ yields in the data.

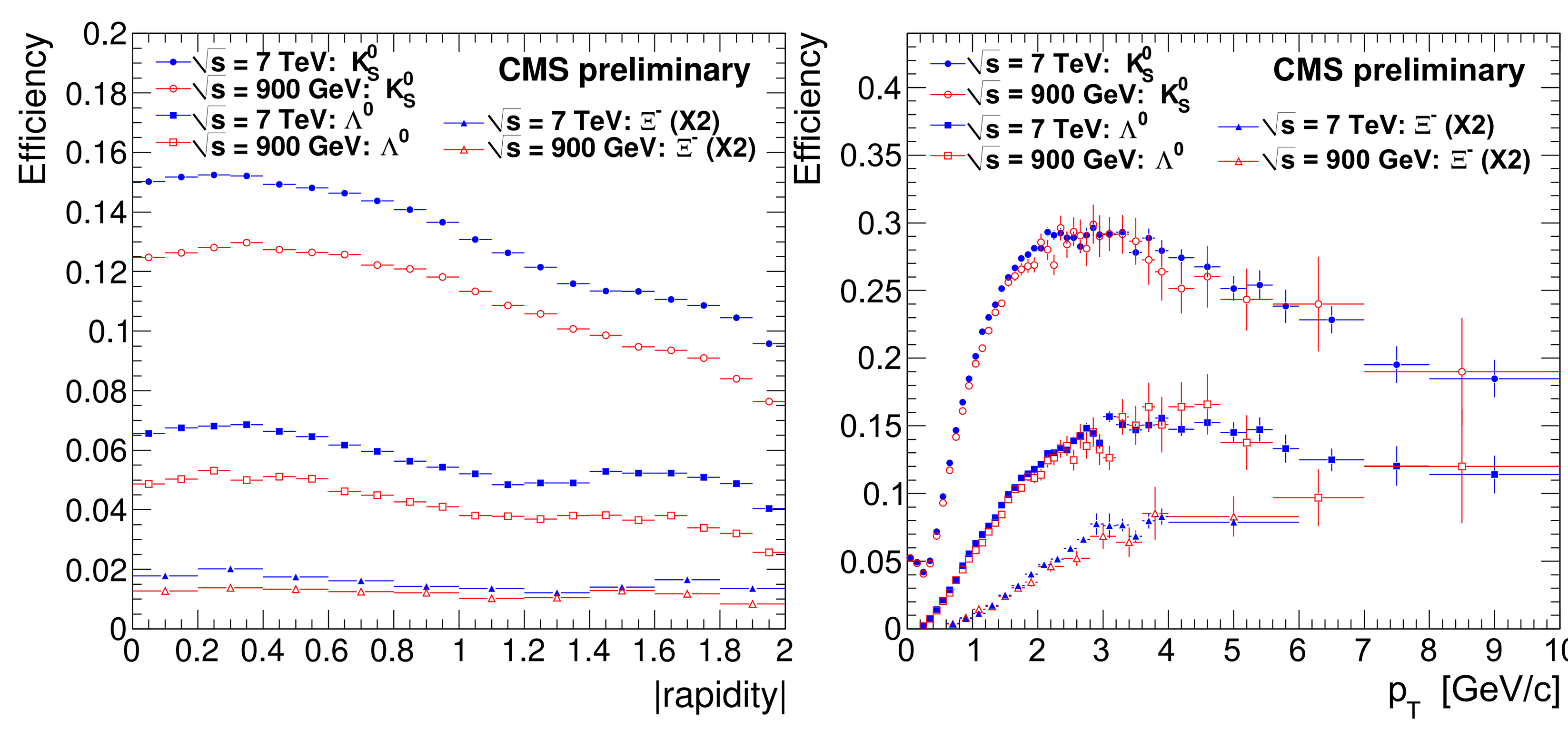

Fig. 2: Total reconstruction efficiency as a function of $|y|$ and p_T for K^0_S, Λ, and Ξ^- produced promptly in the range $|y| < 2$. The Ξ^- efficiency has been multiplied by two for clarity.

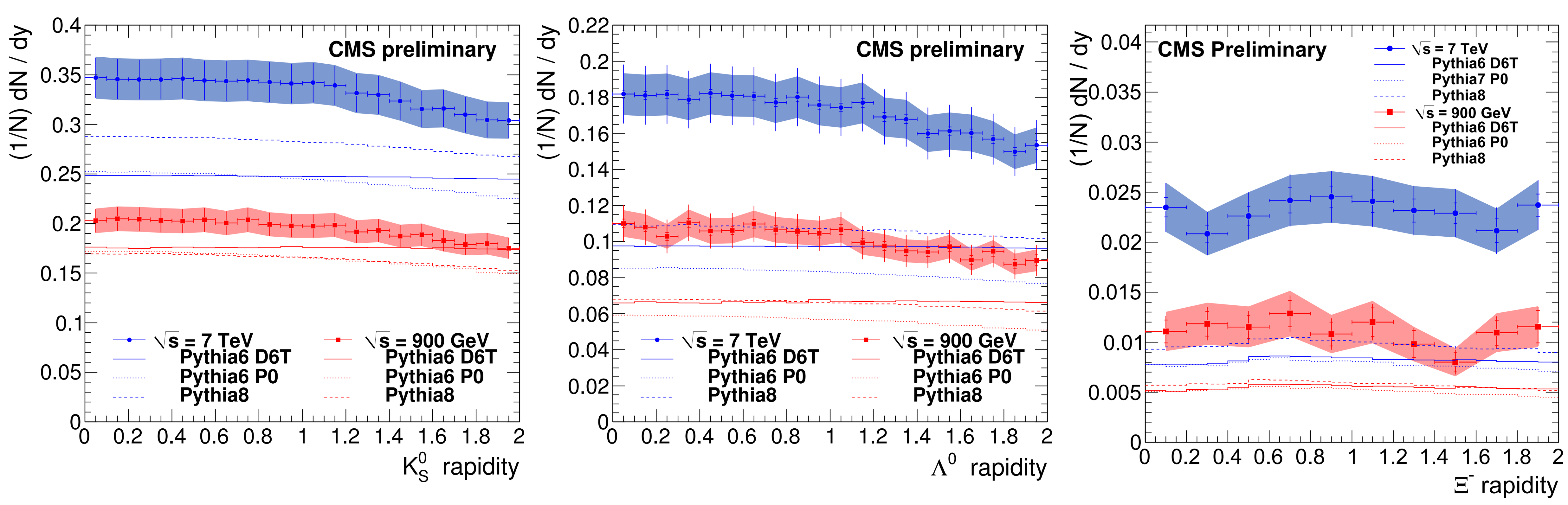

Fig. 3: Corrected yields of K^0_S, Λ, and Ξ^- per NSD event as a function of y for the data and three PYTHIA Monte Carlo samples.

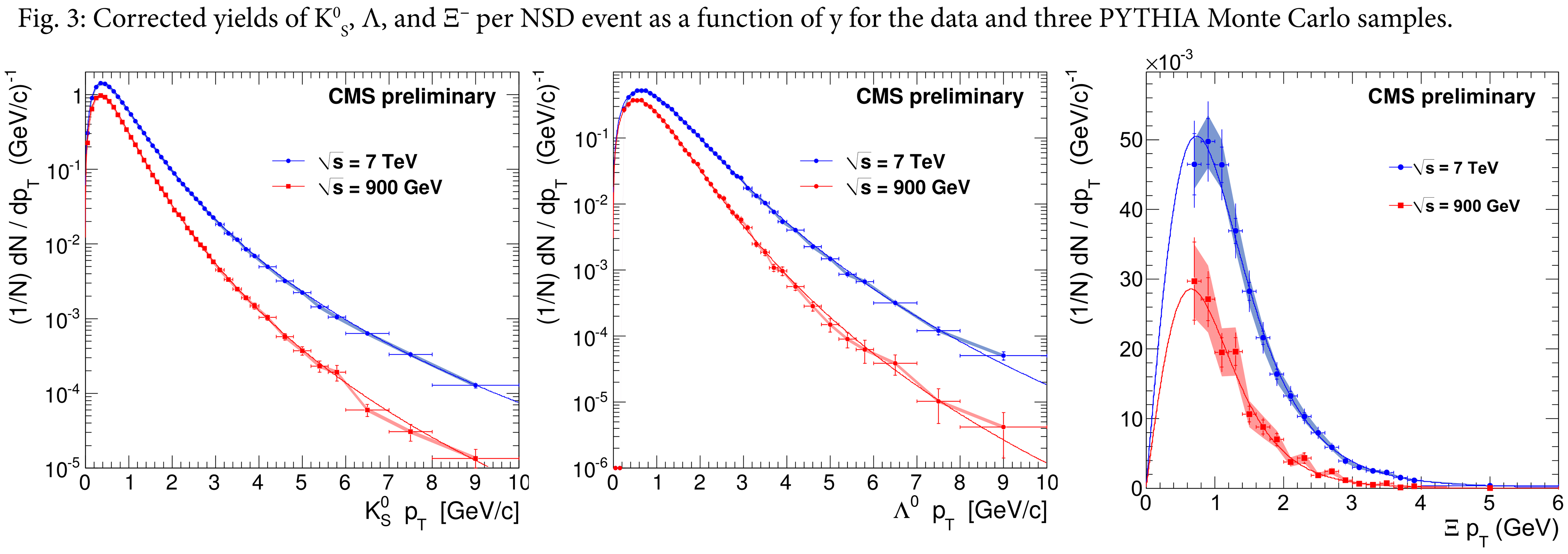

Fig. 4: Corrected yields of K^0_S, Λ, and Ξ^- per NSD event as a function of p_T for the data. The fits with the Tsallis function are also shown.

Results: The results reported here refer to NSD interactions. The NSD raw events were corrected for the trigger efficiency and the fraction of non NSD events after the selection, using the MC simulation. The corrected number of events amounted to 10.1 M for $\sqrt{s} = 0.9$ TeV and 24.5 M for $\sqrt{s} = 7$ TeV. The corrected K^0_S, Λ and Ξ^- yields are reported as a function of y and p_T, normalized to the number of NSD events, in Fig. 3 and 4, respectively. The y distributions are relatively flat in the central rapidity range, while slowly decreasing at higher values, especially at $\sqrt{s} = 7$ TeV. They show a steeply falling distribution in p_T. The MC does not model well the large increase in the measured production cross sections as the c.m. energy increases from 0.9 to 7 TeV. The deficit in strange particles production gets worse as the particle mass and strangeness increase.

References:

[1] CMS Collaboration, JHEP 02 (2010) 041
[2] CMS Collaboration, Phys. Rev. Lett. 105 (2010) 022002
[3] CMS Collaboration, CMS-PAS-QCD-010-007
[4] CMS Collaboration, JINST 3 (2008) S08004

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Systematical uncertainties and checks: The systematic uncertainties can be divided in three categories: largely uncorrelated errors affecting the shape of the p_T and y distributions, correlated errors that do not affect the overall normalization, and correlated overall normalization uncertainties. Various checks were performed to check the robustness of the analysis, including the use of various MC samples, using a completely different analysis approach with 2D y-p_T binning, larger efficiency but lower purity, different vertex finder, tracking algorithm, beam background rejection and V0 finder. At the end we estimated the systematical erros to be 8.4% for K^0_S, 11.0% for Λ and 14.1% for Ξ^- including the uncorrelated, correlated and normalization errors.