# Strangeness production from strong coherent color fields

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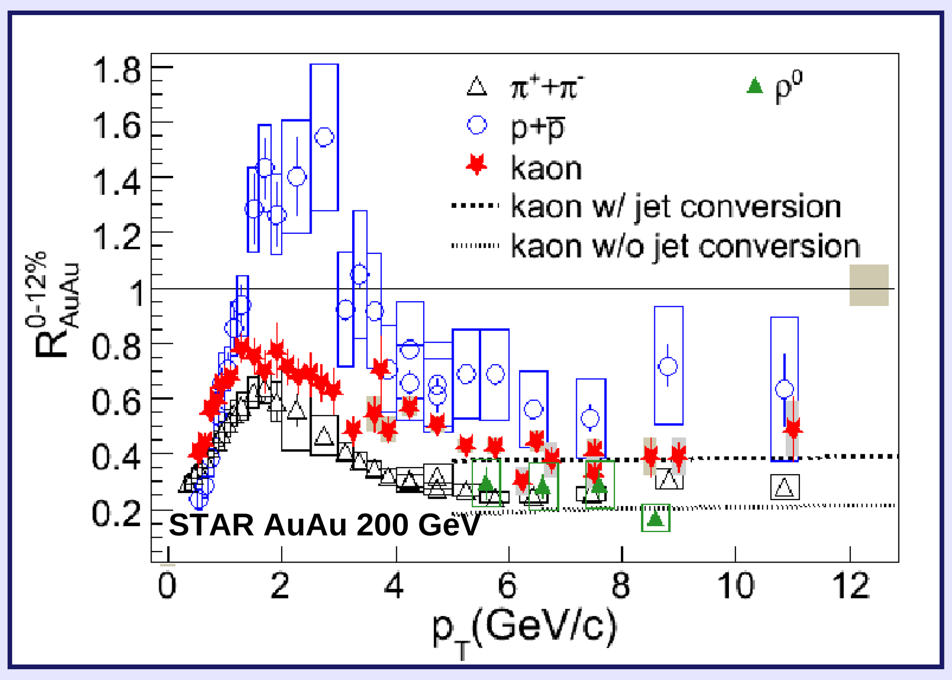
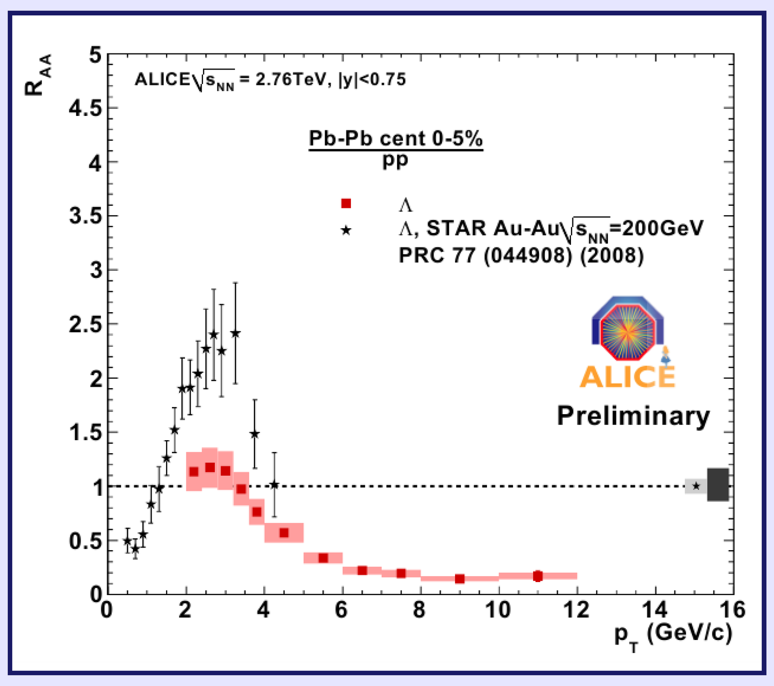
## 1. Motivation




J. Putschke *Nucl. Phys. A* **830** 58C (2009)

Experiments at RHIC have uncovered some interesting facts about baryon production in heavy ion collisions in the mid-to-high $p_T$ region. One of these is the enhanced baryon-to-meson ratios, compared to pp collisions, indicating a need for a non-perturbative treatment of hadron production. Coalescence models combined with pQCD can reproduce such a behavior. However, RHIC data has shown an other anomaly, namely $R_{AA}$(proton) > $R_{AA}$(pion) up to relatively high $p_T$. Such an effect can not be naturally described by a rapidly falling thermal coalescence spectrum. We have shown in a previous work, that including other channels, namely coalescence of quarks and diquarks created by a rapidly changing color field, in a process similar to the Schwinger mechanism of QED, can produce such a feature. Now we extend this work by looking at the predictions of such a model for strangeness production. We will show that the mid-to-high $p_T$ (5-8 GeV) region of Lambda spectra and $R_{AA}$ and Lambda-to-Kaon ratios are well suited for testing the feasibility of such a channel, since including it gives quite different predictions. We will show predictions for LHC conditions, **PbPb collisions at 2.76 ATeV**.

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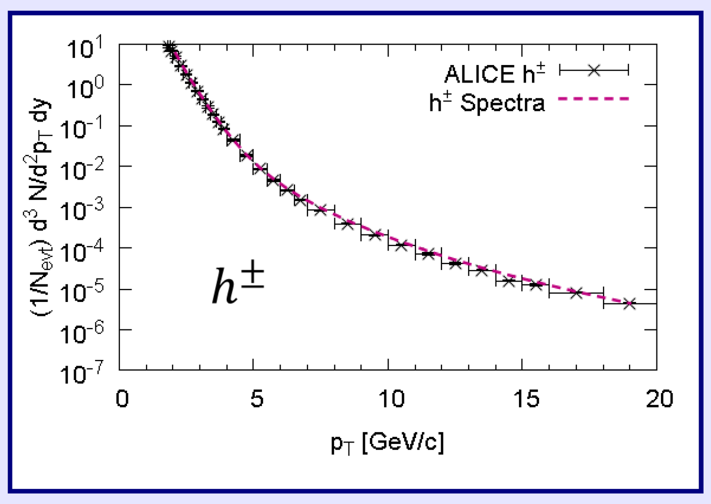
## 2. Theoretical framework

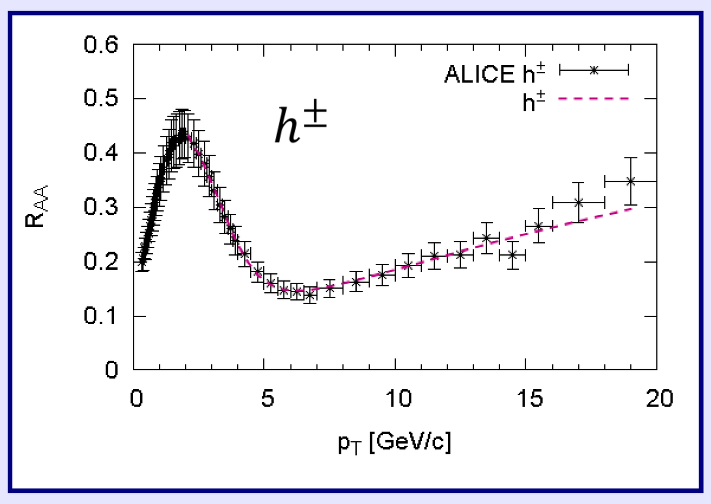
We consider the following three channels for hadron production:

1. Hadrons from jet fragmentation described by perturbative QCD (LO). In PbPb collisions jet-quenching is included (GLV, with opacity: $L/\lambda$ = 5.1).
2. Hadrons from coalescence of thermal quarks (4-flow, $u^\mu$) Temperature: $T$ = 180 MeV (from lattice calculations), Transverse velocity: $v_T$ = 0.64 c, Coalescence volume: $\tau A_T$ = 4043 fm$^3$.
3. Hadrons from coalescence of extra channels: Additional quark-antiquark and diquark-antidiquark pairs produced from the strong color field of gluons, E(t) (time-dependent Schwinger-mechanism).

$$E(t) = \begin{cases} E_0\left(1-\tanh^2\frac{t}{\tau_1}\right), & t \le 0 \\ E_0\left(1+\frac{t}{\tau_2}\right)^{-\delta}, & t > 0 \end{cases}$$

$E_0$ = 2.5 $m_q^2$/g
$\delta$ = 6.1
$\tau_1$ = 0.56 / $m_q$
$\tau_2$ = 0.32 / $m_q$




In PbPb collisions the binary superposition of pp (pQCD) interactions are extended by the formation of an expanding thermal fireball of quarks and antiquarks (T, $u^\mu$), and the appearance of an early state gluonic color field decaying into pairs. Quarks and diquarks coalesce into hadrons, enhancing the fragmentation yield.

The parameters are chosen to reproduce the unidentified hadron spectra. Than the model can give predictions on the identified spectra, hadron ratios and $R_{AA}$.

The theoretical pp reference is given by a pure pQCD calculation. This could introduce a systematic error in the lower $p_T$ regions of our $R_{AA}$ plots, giving a higher value, since the non-perturbative hadron yields have been neglected in the pp reference. The plots on yields and particle ratios are unaffected by this effect.

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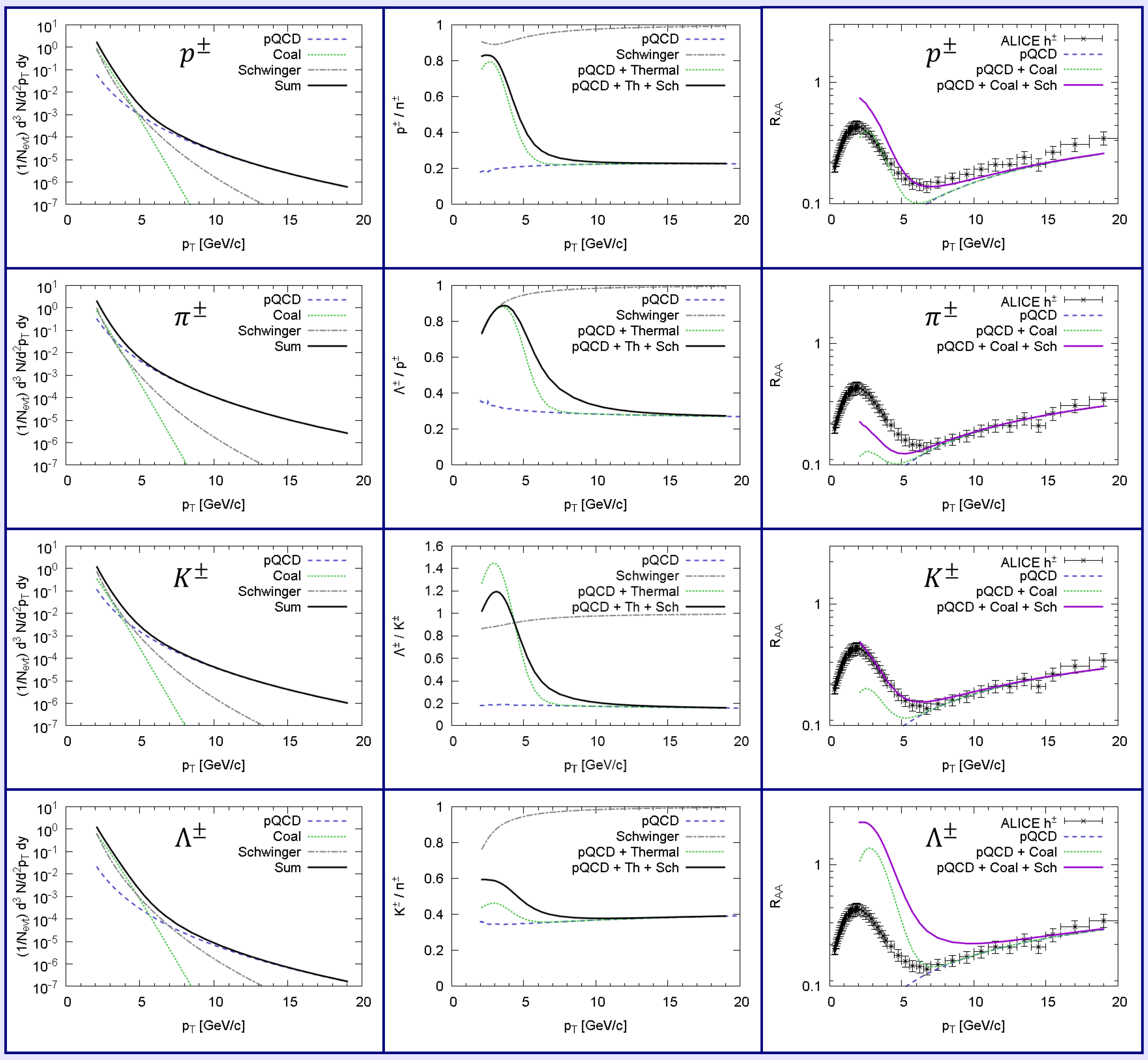
## 3. Numerical Results




## 4. Discussion

The yields and ratios and the contributions of the different channels to them are plotted to the left.

The main qualitative features of the predictions are the following:

**a)** The existing data on unidentified hadron spectra, and pions can be reproduced.

**b)** $R_{AA}$(proton) > $R_{AA}$(pion)

The behaviour shown by earlier RHIC data. Up to ~6 GeV if only coalecence is included, but up to ~8-10 GeV if the Schwinger mechanism is also important. Data on identified proton spectra, $R_{AA}$, and Proton-to-Pion ratios in PbPb collisions at 2.76 ATeV is thus needed.

**c)** $R_{AA}$(Lambda) > $R_{AA}$(proton)

This is mostly because our non-perturbative models give quite similar spectra for the two species, but the pp reference, which is pure pQCD fragmentation, is quite different for them, meaning data on identified Lambda and Proton spectra in pp collisions at 2.76 ATeV would be helpful to sorting this behavior out.

**d)** The sensitivity of the Lambda-to-Kaon ratio on the new channels, which makes it a good candidate for testing such models. Data on Lambda-to-Kaon ratios in PbPb collisions at 2.76 ATeV the mid-to-high-$p_T$ region is much needed.

Future investigations will include charm production from these mechanism, concentrating on D mesons.

## 5. Acknowledgements

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