Measurements of identified hadron production at high p_T in p+p collisions at RHIC-STAR

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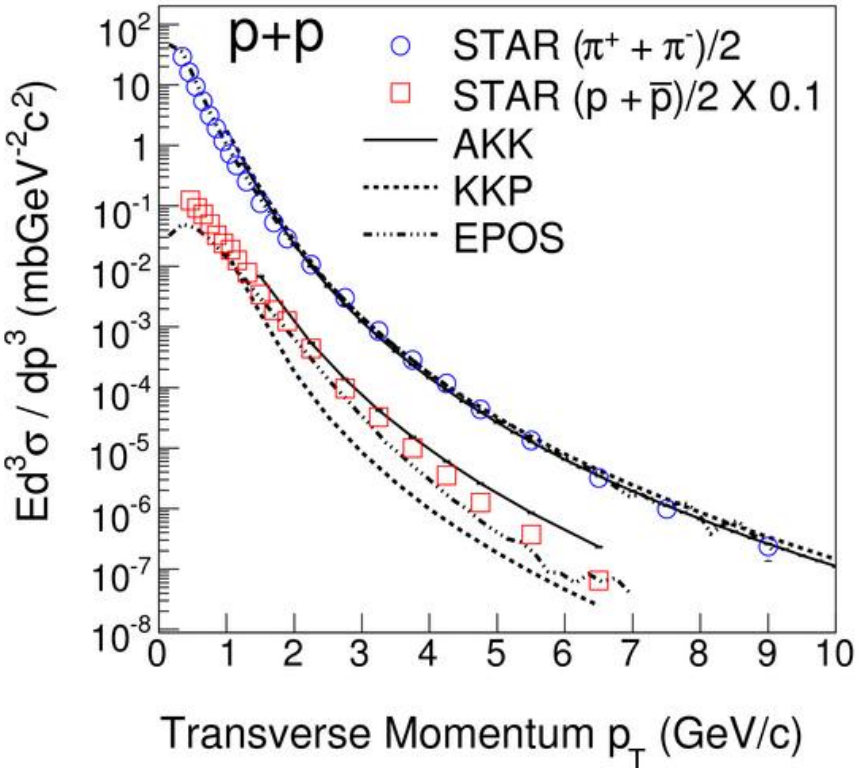
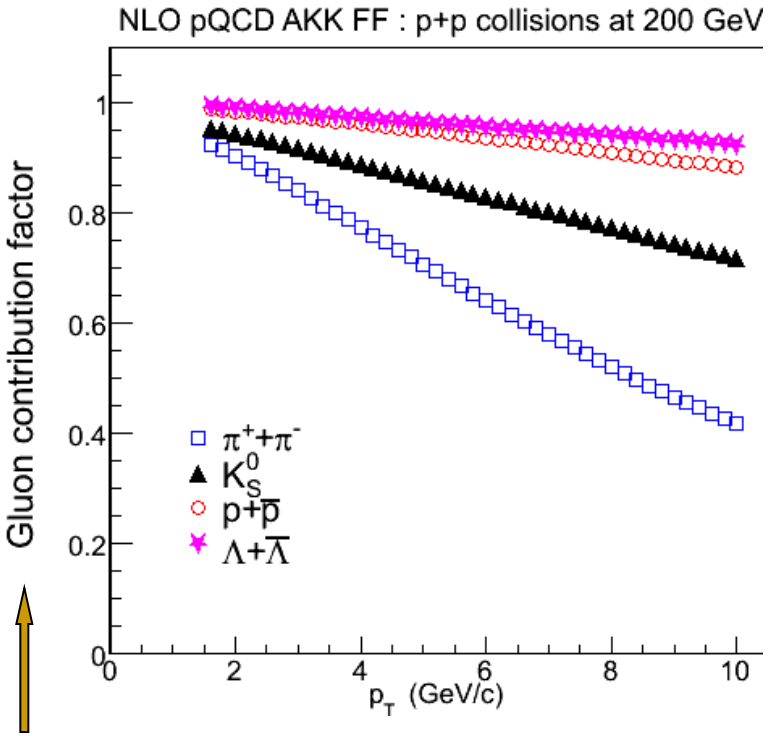
Outline

- **Motivation**
  - ✓ Extend identified hadron spectra study up to higher p_T range.
  - ✓ Good constraints to pQCD calculations.
  - ✓ Baseline for study of nuclear modification factor (R_{AA}) in Heavy Ion Collisions.
- **Data analysis**
  - ➢ Identify charged π, K, p($\bar{p}$) by ionization energy loss (dE/dx)
  - ➢ Reconstruct $K^0_S \rightarrow \pi^+ + \pi^-$ with one triggered pion
- **Results & Summary**

Good constraints to pQCD calculation





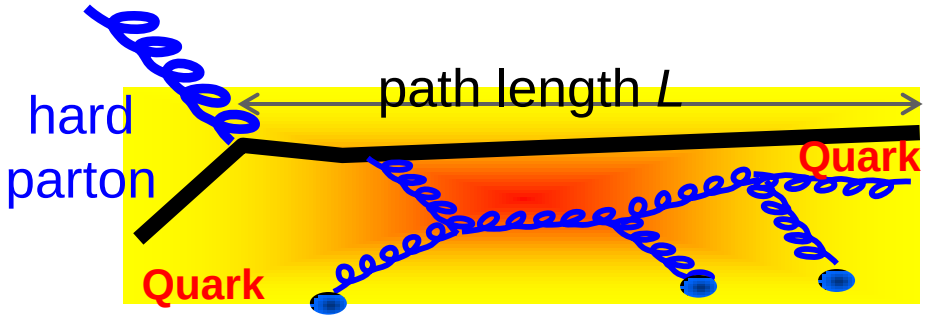
$N_g(i)/ (N_g(i) + N_q(i))$; i = π, K, p…

Large gluon contribution (~ 90%) to produced baryons @ high p_T;
Substantial quark contribution (~ 40%) to produced mesons @ high p_T.

J. Adams et al. Phys. Lett. B 637:161-169, 2006
AKK: S.Albino, B. A. Kniehl, G. Kramer, NPB 725 (2005) 181;
KKP: Bernd A. Kniehl, G. Kramer, and B. Potter, Nucl. Phys. B597:337-369, 2001;
EPOS: K.Werner, F. Liu and T. Pierog, hep-ph/0506232; ZhangbuXu (for STAR) aXiv:0806.0200

Baseline for study of R_{AA} in HIC

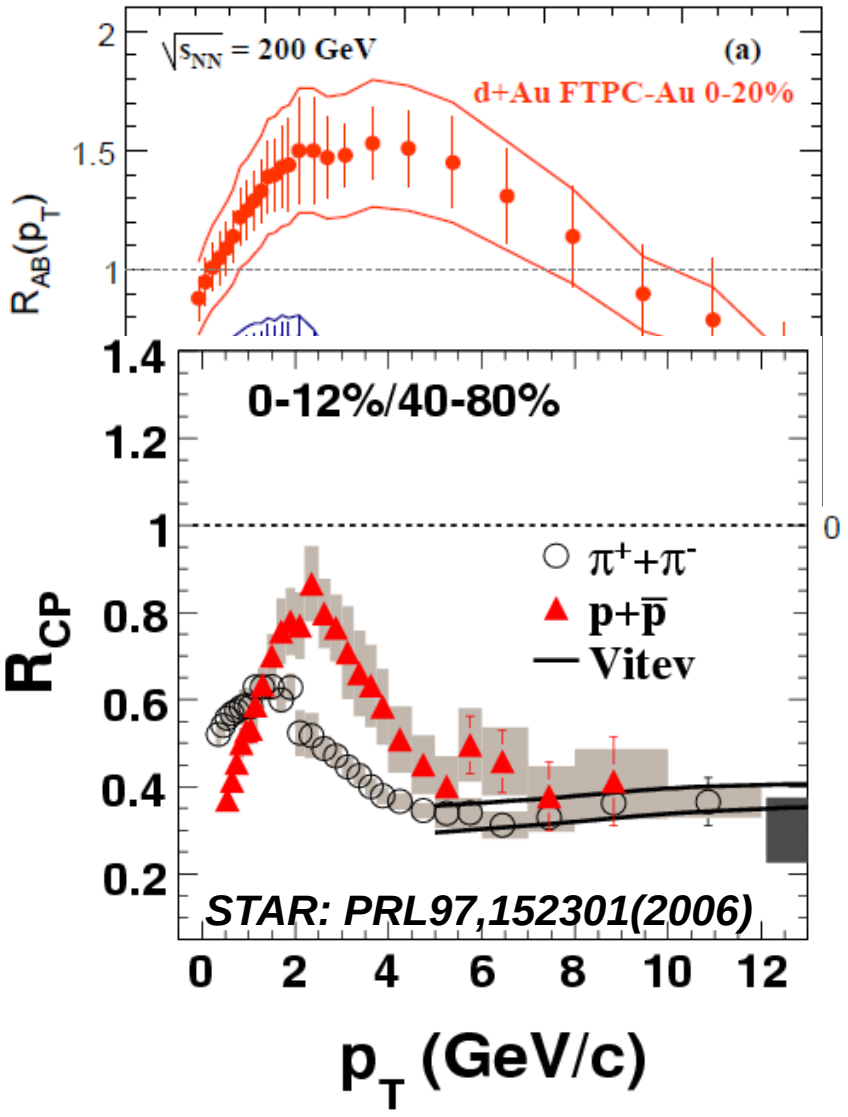
$$R_{AB} = \frac{1}{N_{bin}} \frac{d^2 N^{AB} / dp_T d\eta}{d^2 N^{pp} / dp_T d\eta}$$



Color charge effect of parton energy loss

In pQCD: $\frac{\Delta E_g}{\Delta E_q} \sim 9/4$

$R_{AA}(p) < R_{AA}(\pi)$



Jet Conversion & Jet hadrochemistry

Jet parton scatters on medium parton and changes flavor.

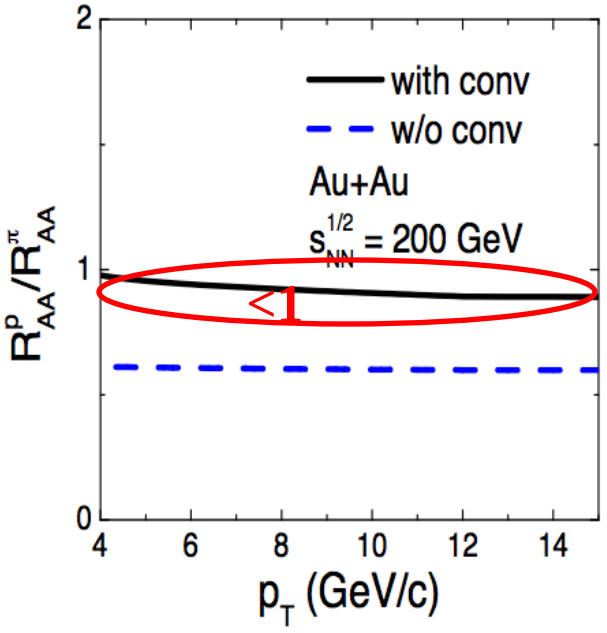
q + qbar → g + g

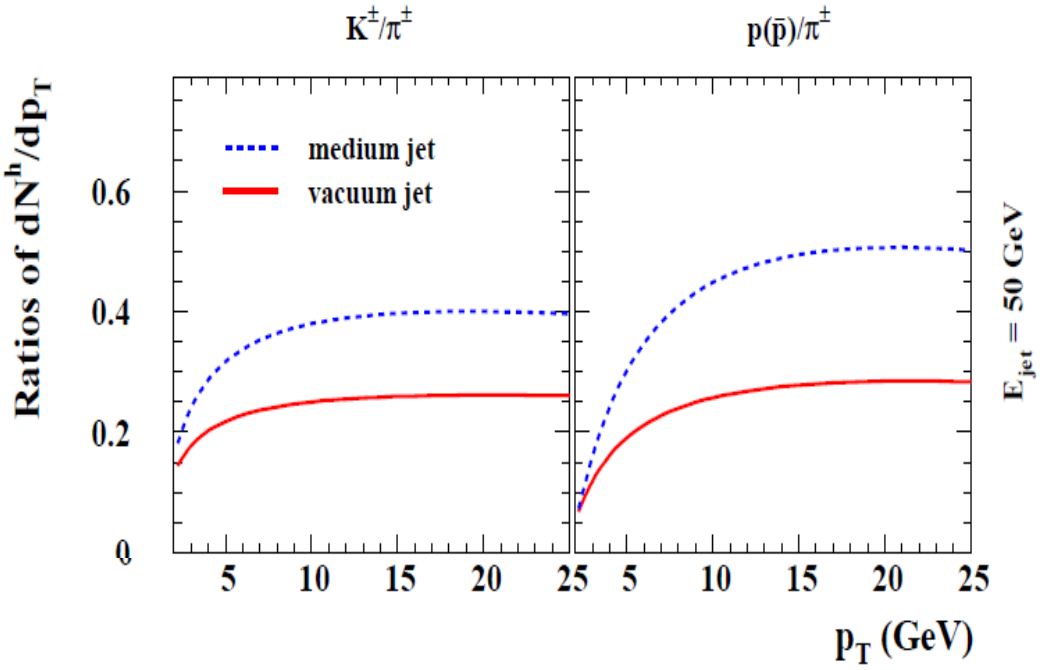
q(qbar) + g → g + q(qbar)

Enhanced parton splitting in medium

↓

Enhance p/π and K/π ratios in A+A jets for LHC



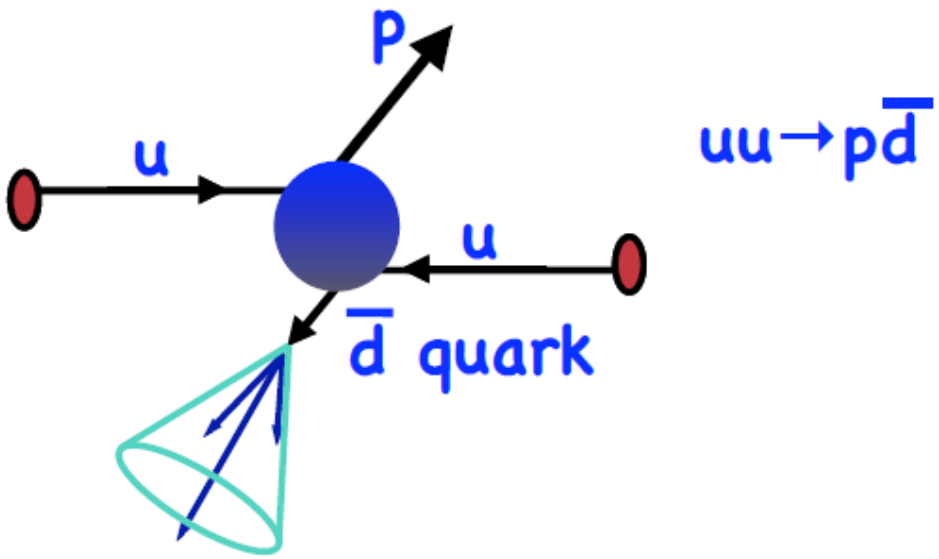


W. Liu, R.J. Fries, Phys. Rev. C77 (2008) 054902

W. Liu, C.M. Ko, B.W. Zhang, Phys. Rev. C 75, 051901 (2007)

S.Sapeta and U.A. Wiedemann, arXiv:0707.3494

Color transparent of direct proton

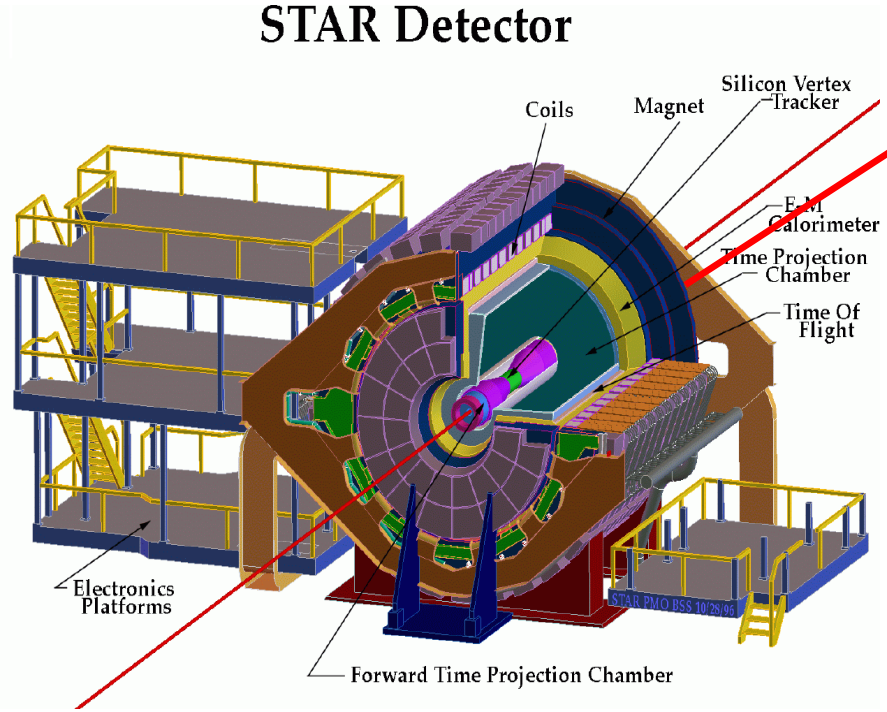


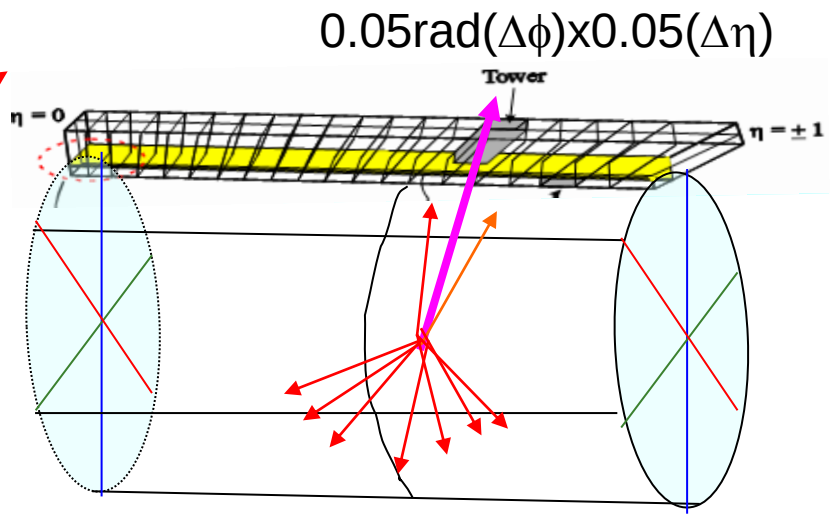
- color singlet proton directly produced within hard scattering
- size of proton decreases with increasing p_T: color transparent
  - proton exits collision region without interacting, like a direct γ
  - $R_{AA}(\text{proton}) > R_{AA}(\pi)$

Anne M. Sickles @QM2009

Brodsky & AMS PLB 668 111 (2008)

Experiment and Data set





- **Time Projection Chamber (TPC)**
- **Electro-Magnetic Calorimeter (EMC)**

Data set:

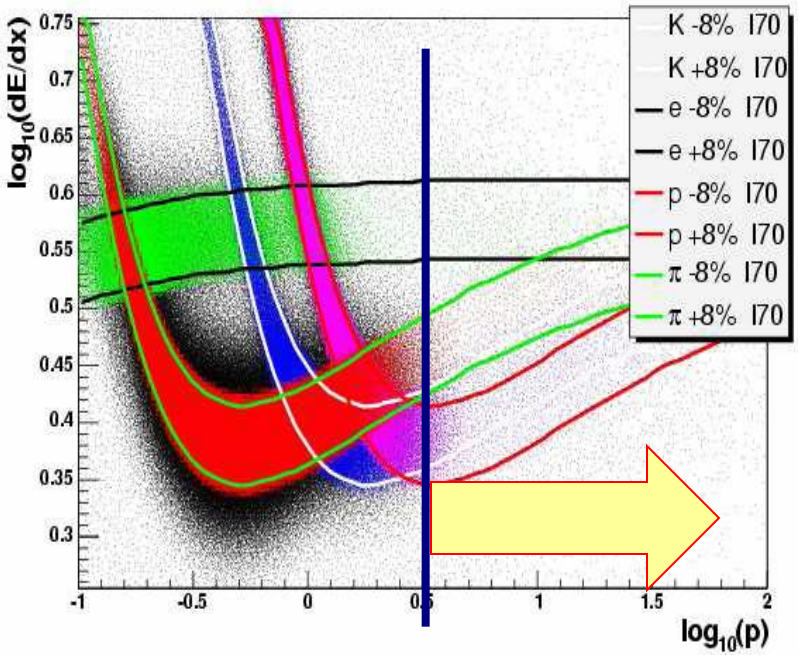
EMC Triggers in run5 pp @ 200GeV

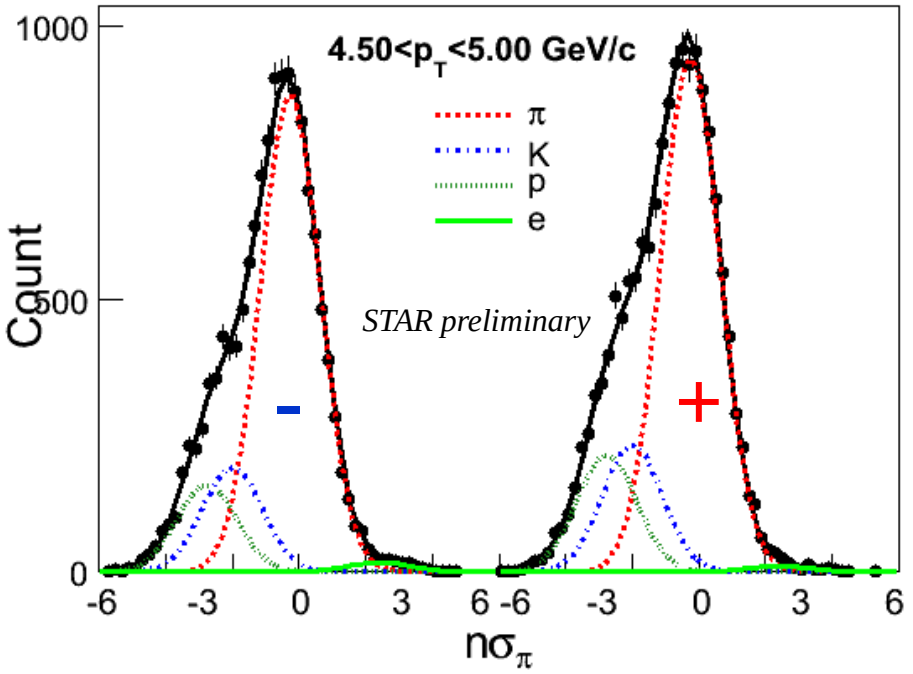
Jet Patch trigger: $E_{Ttot} > 6.4$ GeV

High Tower trigger: $E_T > 2.5$ GeV

$E_T > 3.6$ GeV

$\pi^{\pm}/K^{\pm}/p(pbar)$ with dE/dx



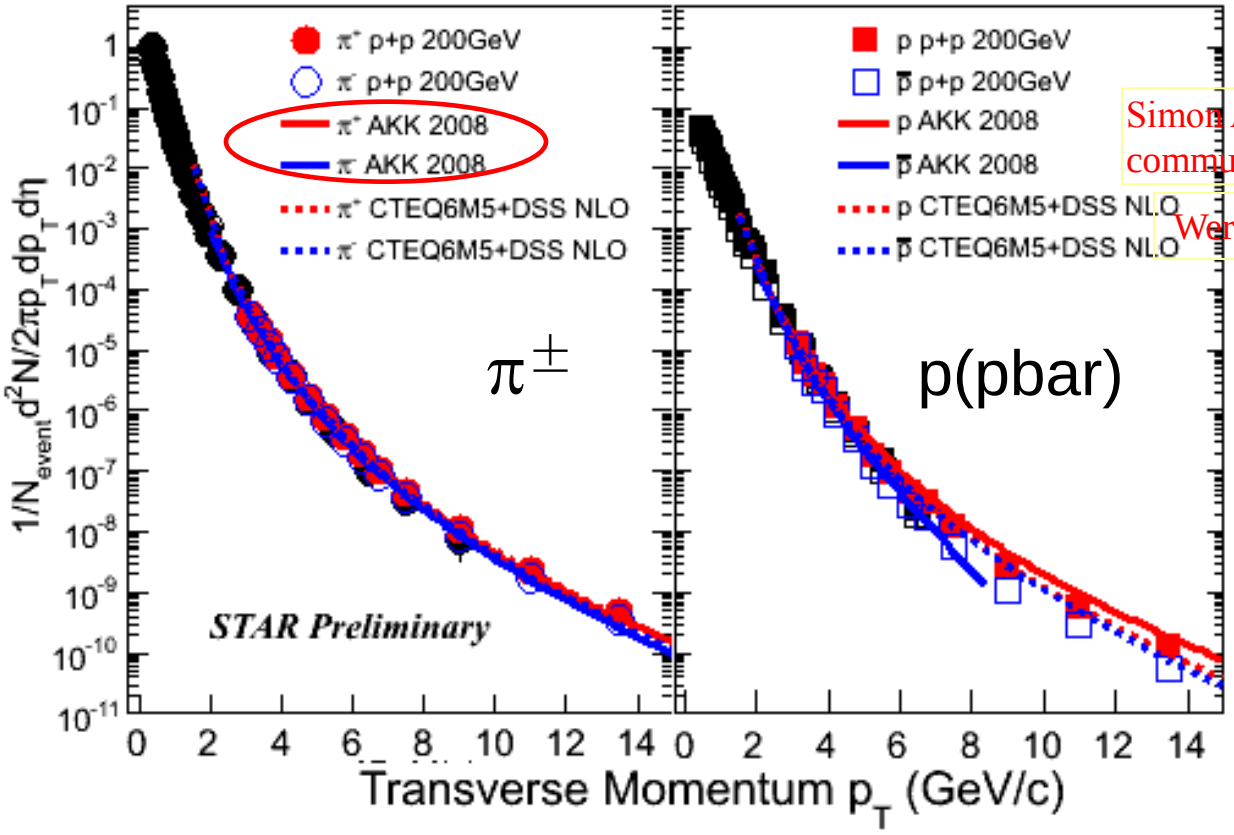


$$n\sigma_{\pi}^{X} = \frac{\log((dE/dx)_X / B_{\pi})}{\sigma_{\pi}}$$

Where $\mathbf{B_{\pi}}$ is the expected mean dE/dx of π from Bichsel function of ionization energy loss in TPC.

Nucl. Instr. & Meth. A 558 (2006) 419 Nucl. Instru. & Meth. A 614 (2010) 28–33

Constraint for pQCD calculation



Simon Albino's private communication

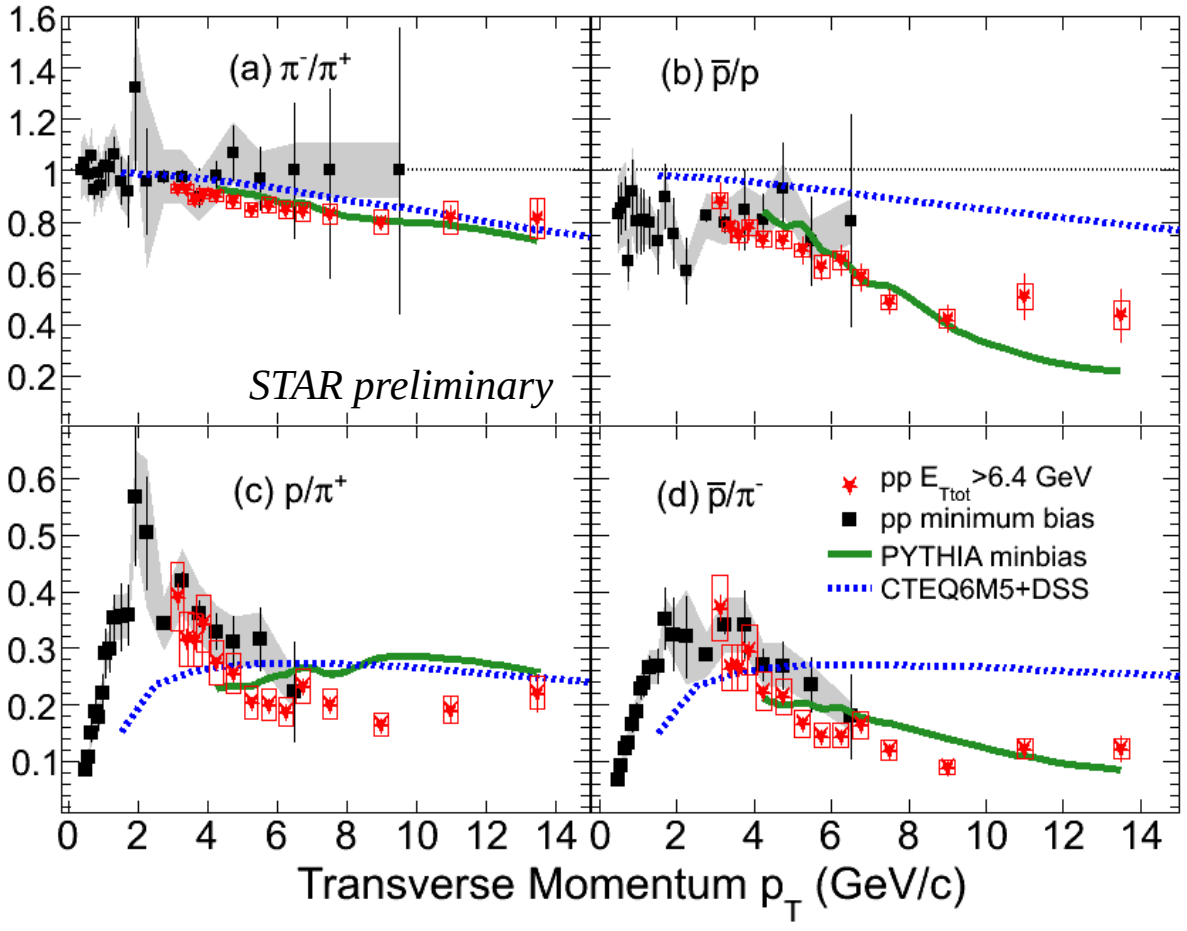
Werner Vogelsang

Our data can provide a better constraint on Fragmentation Function!

[1] S.**A**lbino, B. A. **K**niehl, G. **K**ramer, Nucl.Phys.B803:42-104,2008, arXiv:0803.2768

[2] **D**aniel de Florian, Rodolfo **S**assot and Marco **S**tratmann, arXiv: 0707.1506 [hep-ph]; Phys.Rev.D76:074033,2007. DSS Fragmentation Functions –provided by W. Vogelsang

Particles Ratios in p+p collisions



Experimental data:
(Consistent with published data)

1. **π^-/π^+, $\bar{p}/p$:** decrease with p_T, indicates a significant quark jet contribution not only to meson but also to baryon.
2. **p/π and $\bar{p}/\pi$:** p/π^+ ~0.2, and $\bar{p}/\pi^-$~0.1

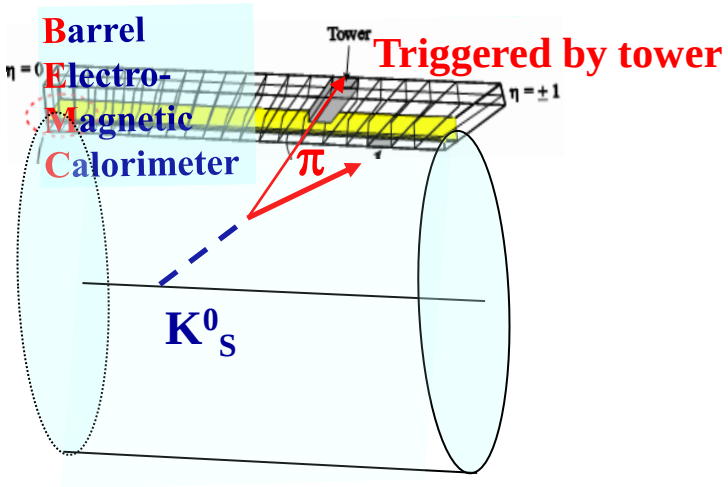
Compare to models:

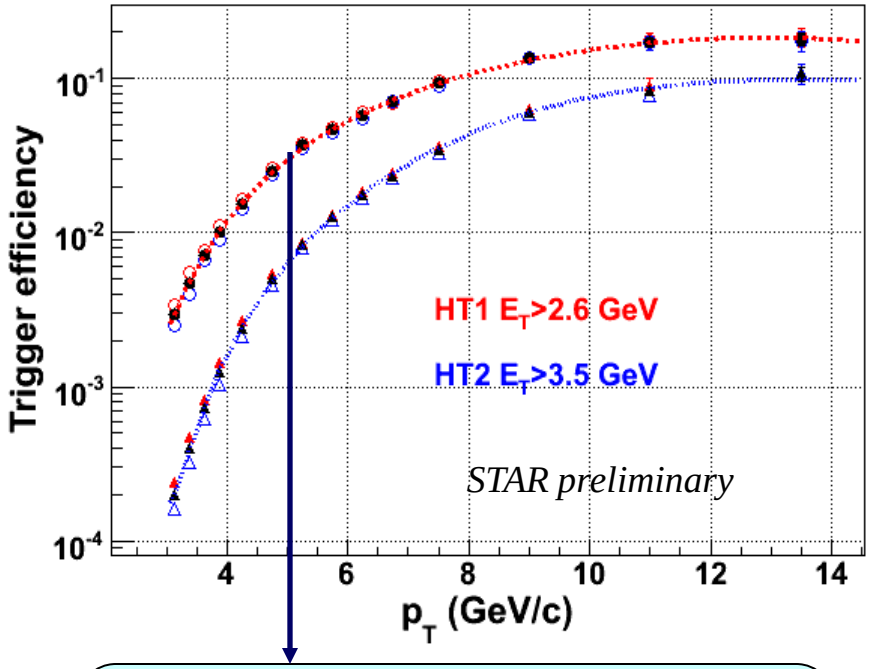
1. **PYTHIA**(v6.205) describe ratios reasonably.
2. **DSS** over-predicts anti-protons relative to pions and protons.

J. Adams et al. *Phys. Lett. B* 637:161-169, 2006

Triggered K^0_S at high p_T

$K^0_S \rightarrow \pi^+ + \pi^-$ (trigger)





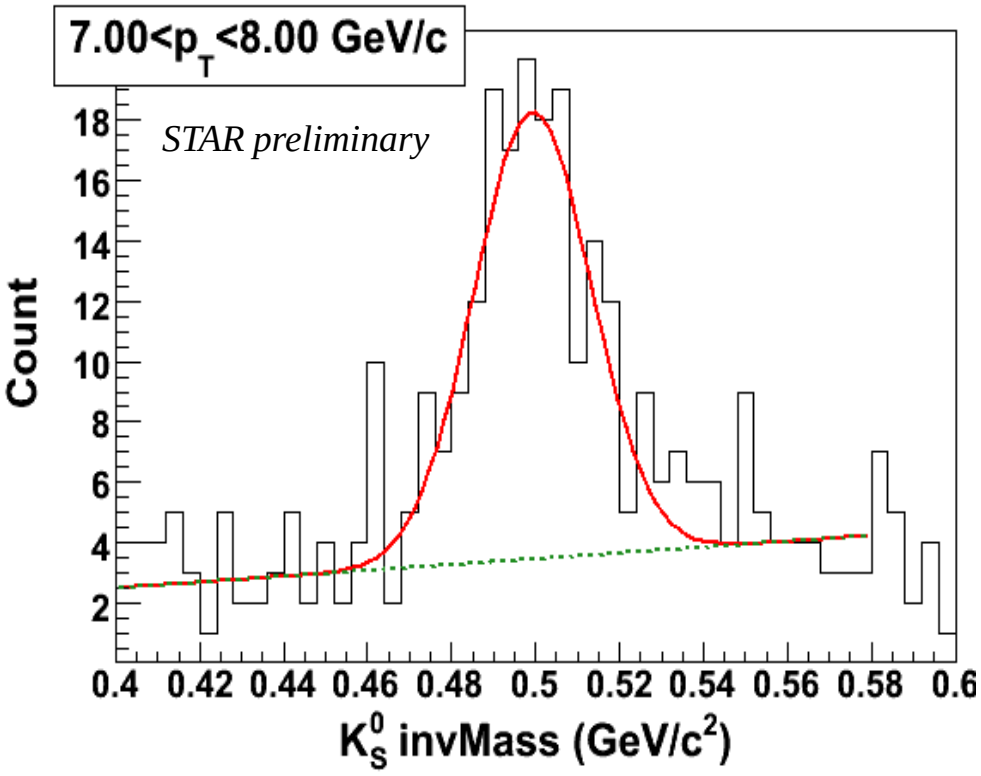
A factor of **100** enhancement

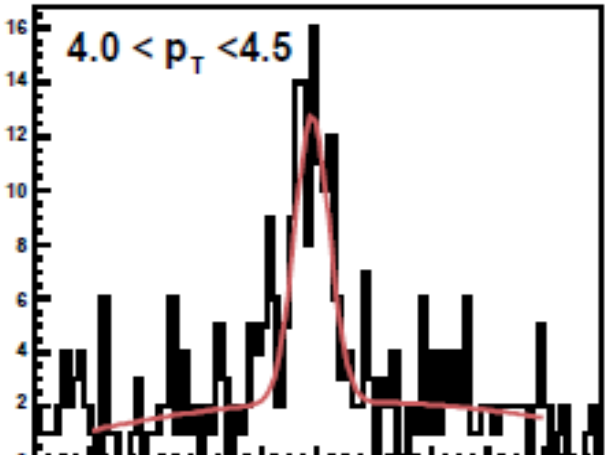
Given p_T=5 GeV/c, **~5.6M HT1** triggered events are equivalent to L(0.64 pb^{-1})*σ(30mb)*effTrg(3%)/effTrk(90%) **~600M** minibias events.

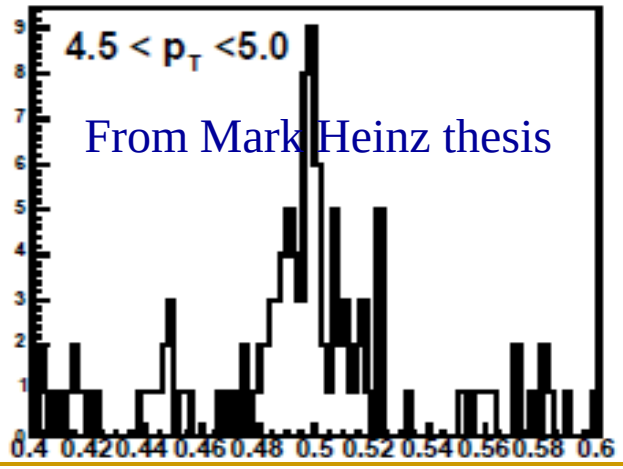
Comparison of K^0_S signal

RunV **5.6M** EMC trigger events

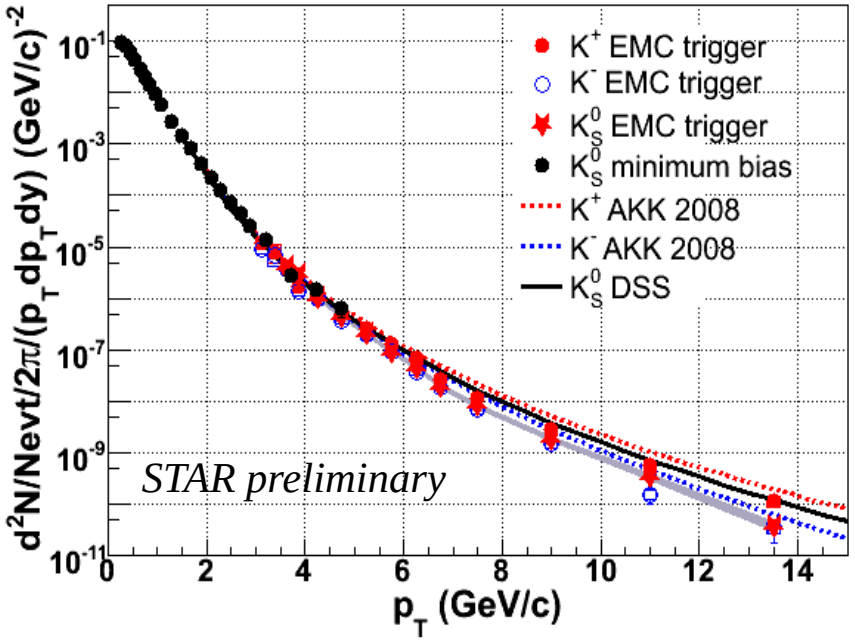
RunII **10.26M** minibias events

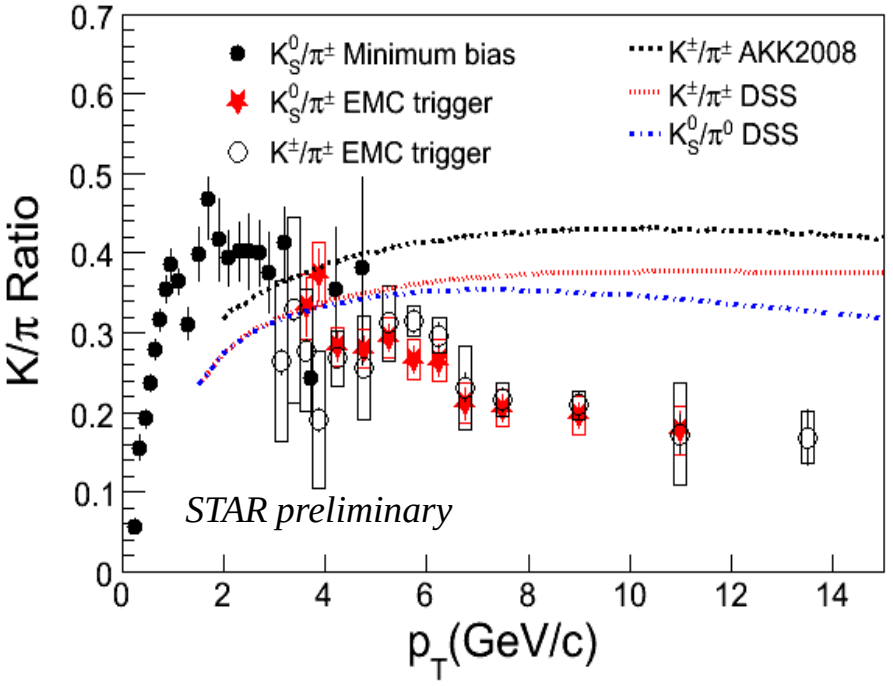






Kaon in p+p collisions





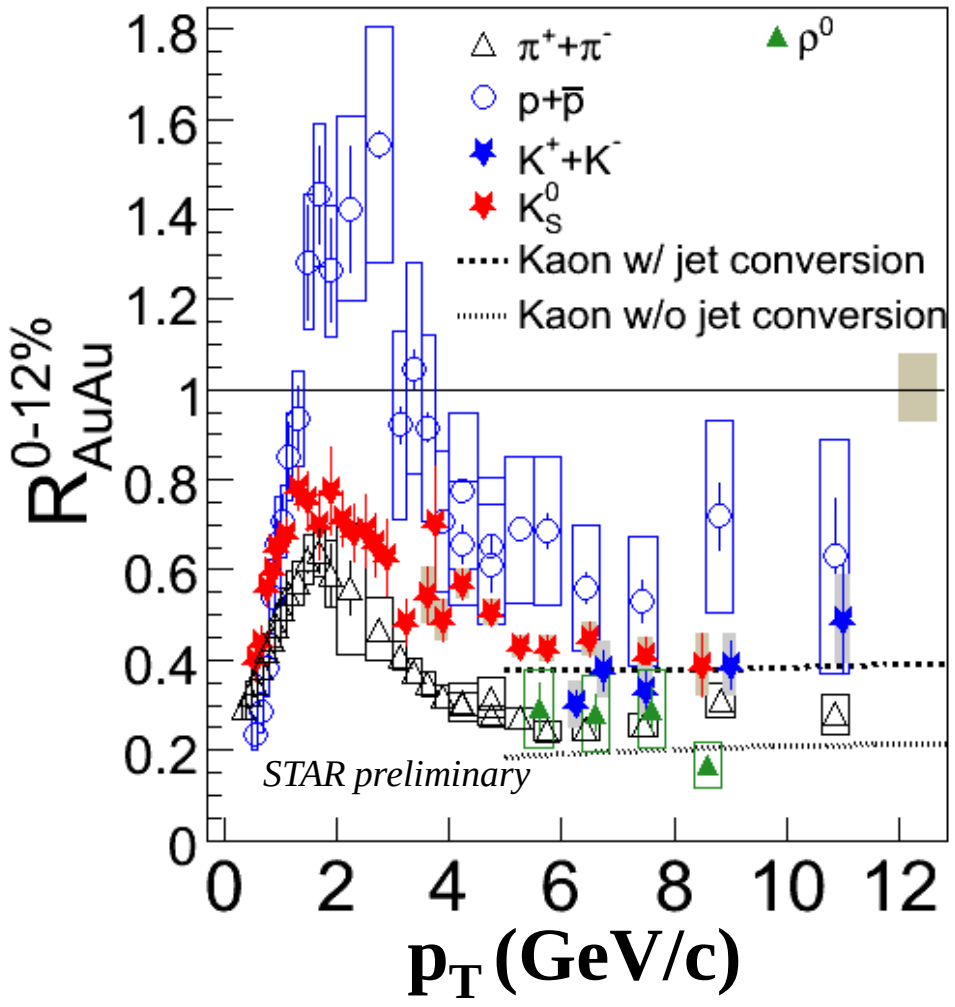
Charged and neutral kaons are extended up to 15 GeV/c in p+p collisions.

Charged and neutral kaons are consistent.

B. I. Abelev et al. *Phys. Rev.*, C75:064901, 2007

AKK: S. Albino, B. A. Kniehl, and G. Kramer, **arXiv: 0803.2768v2**
DSS: Daniel de Florian, Werner Vogelsang, and Federico Wagner, **arXiv: 0708.3060v3**

R_{AA} for π, K and p



1. R_{AA}(proton)>R_{AA}(pion)@ high p_T

➔Which is in contrast to the prediction of color charge dependence of **Energy Loss.**

How the gluon jet/quark jet interact with the medium created in Au+Au collisions?

2. $R_{AA}(K) \sim 0.4$ at high $p_T > 5.0$ GeV/c

➔Consistent with the prediction of jet conversion by interaction with the medium in Au+Au.

3. $R_{AA}(\pi) \sim R_{AA}(\rho^0)$ at high p_T

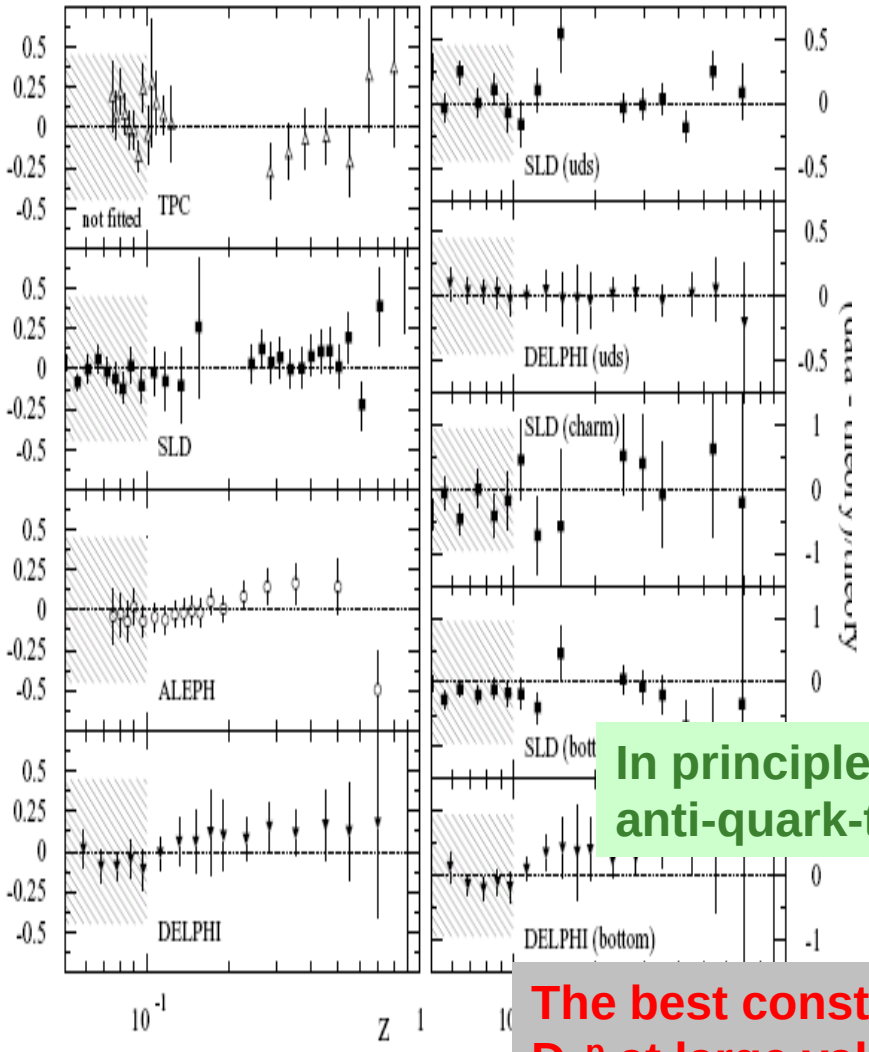
➔Light quark mesons have no mass effect

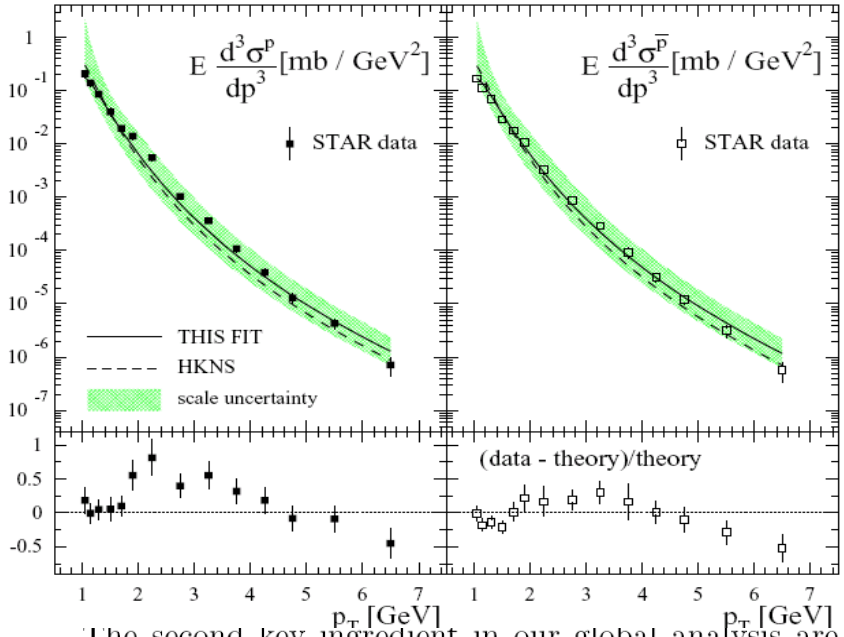
Summary

- ✓ Extend identified hadron spectra up to **15 GeV/c**.
- ✓ Indicates a significant **quark jet contribution** to baryon from decrease of pbar/p with p_T .
- ✓ Provide constraints for **Fragmentation Function**.
- ✓ Provide baseline for **nuclear modification factor** in HIC➔ How the **gluon /quark** jet interact with the medium.

Thanks for your attention!

Global Fit





The second key ingredient in our global analysis are the single-inclusive hadron production data from proton-proton collisions at BNL-RHIC taken by STAR [10] at

In principle, allow to separate quark-to-proton and anti-quark-to-proton fragmentation functions

and anti-quark-to-proton fragmentation functions in the fit. However, at the presently accessible range of transverse momenta p_T and at mid-rapidities the production

The best constraint on the gluon fragmentation function D_g^p at large values of z currently available.

tion D_g^p at large values of z currently available. Figure

Daniel de Florian, Rodolfo Sassot and Marco Stratmann
arXiv: 0707.1506 [hep-ph]; Phys.Rev.D76:074033,2007.
DSS Fragmentation Functions –provided by W. Vogelsang