К пониманию усиленного рождения странных частиц в ядро-ядерных взаимодействиях при высоких энергиях

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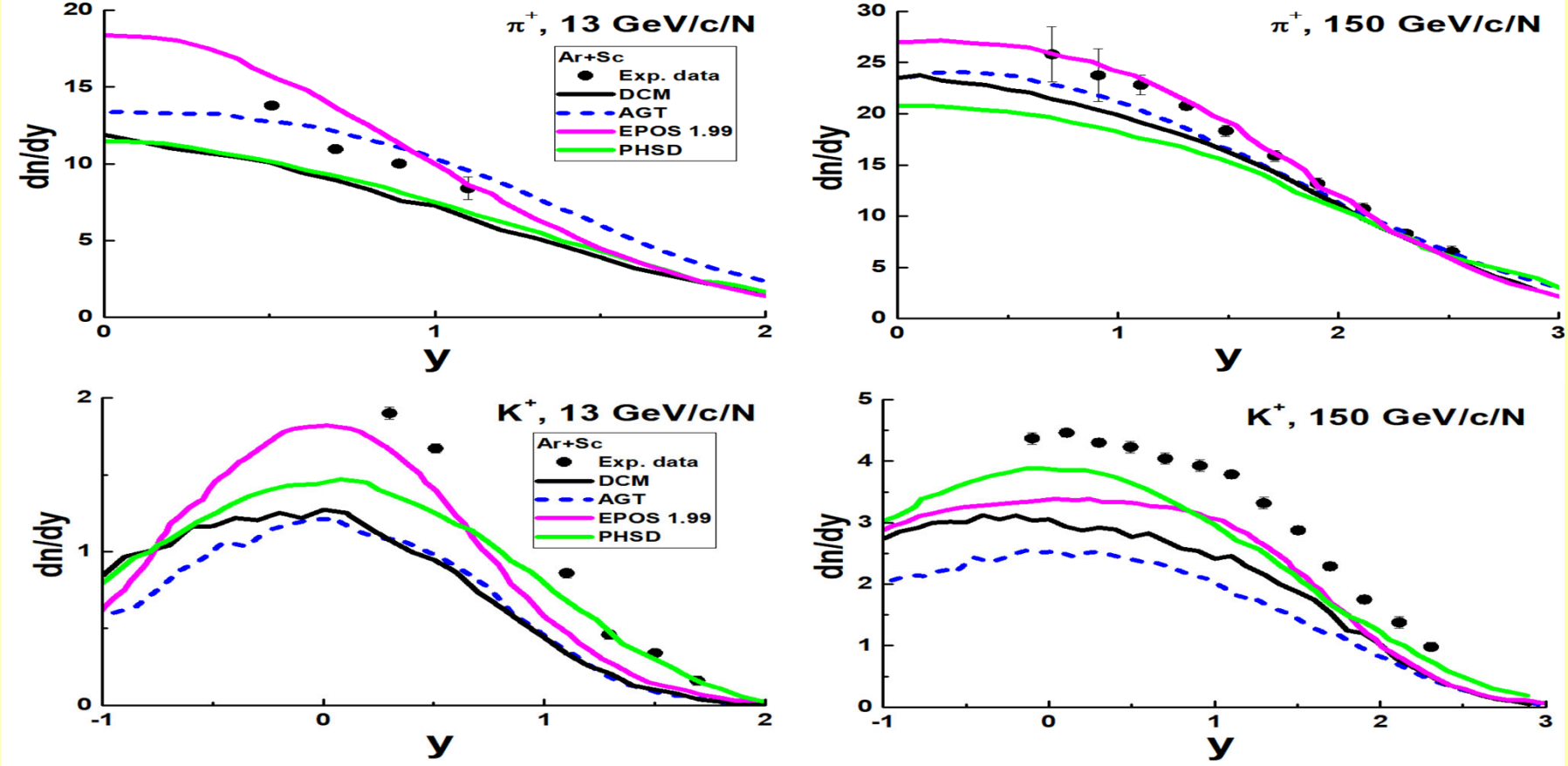
Measurements of π+-, K+-, p and anti-P spectra in **Ar-40 + Sc-45 collisions at 13A to 150A GeV/c**
NA61/SHINE Collaboration H. Adhikary(Jan Kochanowski U.) et al. Eur. Phys. J. C 84 **(2024)** 4, 416

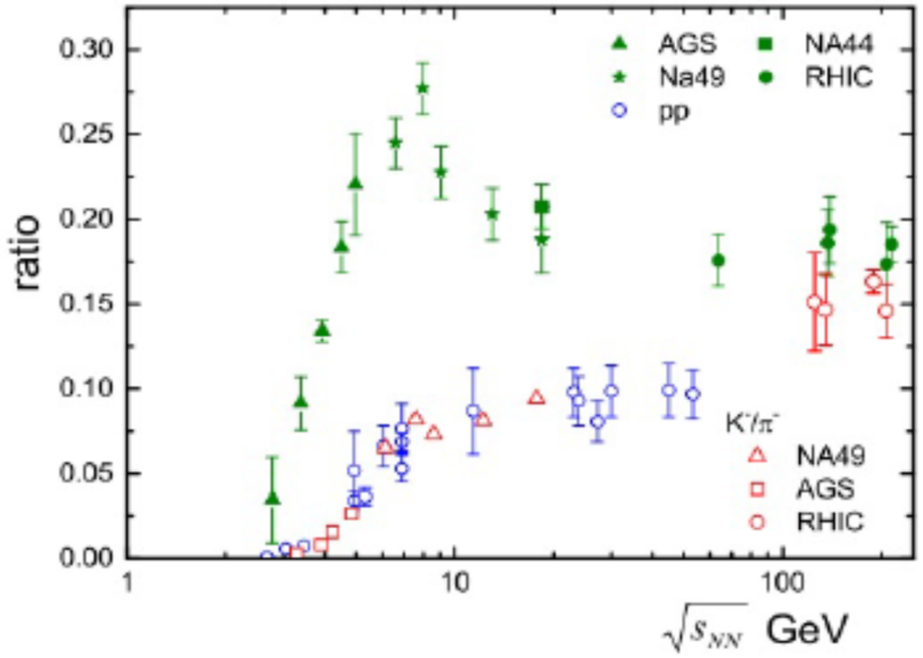


All Monte Carlo models including DCM (Dubna Cascade Model) and AGT (Amelin-Gudima-Toneev one) essentially underestimate K-meson yields for these interactions!

Enhanced strange particle production in hadron-nucleus and nucleus-nucleus is a problem during last 40 years - horn effect!

The 'horn': experiments

Firstly, the "horn" was described by the NA49 Collaboration (NA49 Collaboration, PRC 66, 054902,2002) and then it was shown that data can be placed on the same curve (STAR, AGS)



K^+/π^+ and K^-/π^- ratios in nucleus-nucleus interactions

There are some theoretical explanation of the enhancement.

- the statistical model: hadron resonances + σ - meson (implies the existence of the critical temperature for hadrons, the hadron phase transition) $\Rightarrow$ the qualitative reproduction of the peak (Andronic PLB 673, 142 (2009)).
- the SMES (the Statistical Model of Early Stages): a jump in the ratio is a result of the deconfinement transition: when deconfinement transition occurs the strangeness yield becomes independent of energy in the QGP ($m_s \rightarrow m_{s0}$) (M. Gazdzicki, M.I. Gorenstein, Acta Phys. Pol. B 30, 2705 (1999)).
- the microscopic transport model: with the hadron phase only can not reproduce experimental data (W. Ehehalt and W. Cassing, NPA602, 449 (1996); W. Cassing, E. L. Bratkovskaya, PR 308, 65 (1999); H. Petersen et al arXiv:0805.0567 [hep-ph]....)
- the microscopic transport model + the partial restoration of chiral symmetry (A. Palmese, et al. PRC 94, 044912 (2016): the quick increase in the K^+/π^+ appears as a result of the partial chiral symmetry restoration; the decrease is a result of QGP formation.

From report by Yu. Kalinovsky (LIT) at 27 January 2023

We propose a possible explanation in QGS model.

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We propose a possible explanation in QGS model – Quark-Gluon-String model by A.B. Kaidalov.

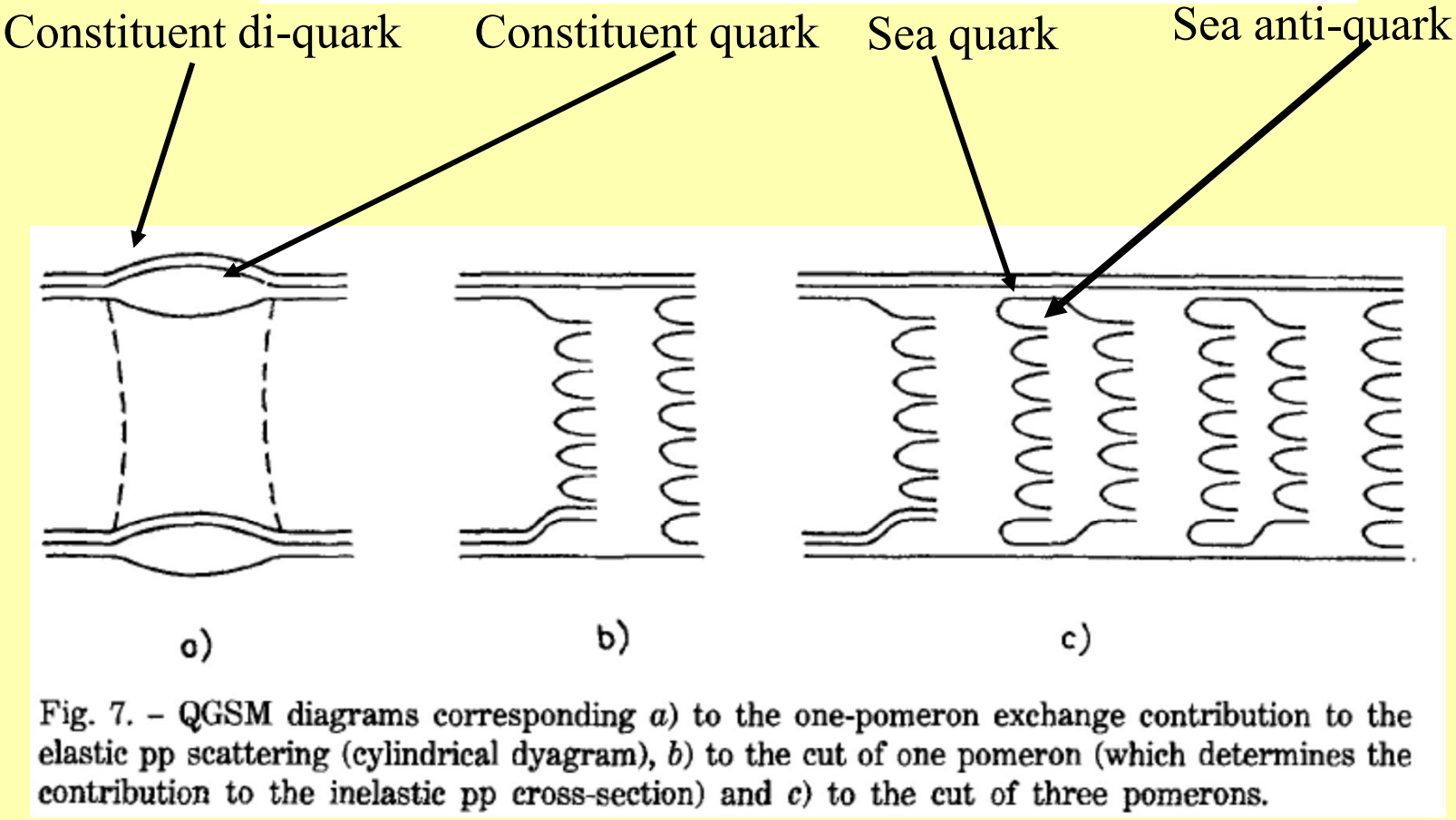


Fig. 7. – QGSM diagrams corresponding *a)* to the one-pomeron exchange contribution to the elastic pp scattering (cylindrical dyagram), *b)* to the cut of one pomeron (which determines the contribution to the inelastic pp cross-section) and *c)* to the cut of three pomerons.

In nucleus-nucleus interactions as in high multiplicity PP interactions multiplicity of sea-quark-sea-antiquark pairs is essentially larger then multiplicity of constituent quark-diquark pairs. For the first ones strangeness suppression Ps-anti-s/Pu-anti-u ~ 1 can be as in QGP!

We propose a possible explanation in QGS model.

QGSM – Quark-Gluon String Model by A.B. Kaidalov implemented in DCM and AGT

AGT – Amelin-Gidima-Toneev model,
a previous version of DCM.

SHIELD – a Monte Carlo Hadron Transport Code
A.V. Dementyev, N.M. Sobolevsky,
IAI, 2017

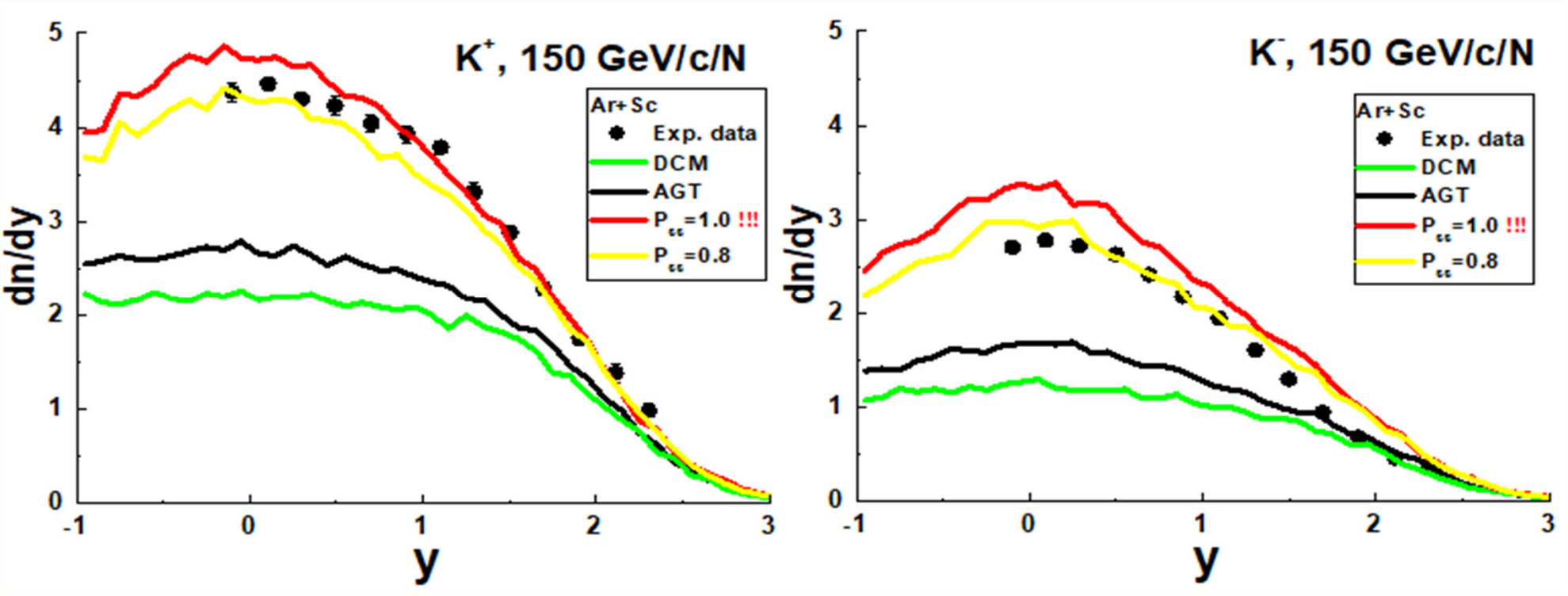
SHIELD-HIT12A - a Monte Carlo particle transport program for ion therapy research
N. Bassler, D.C. Hansen, A.Luhr,
B. Thomsen, J.B. Petersen, N Sobolevsky
Jour. Of Phys. 489 (2014) 12004

User Manual for the Code LA QGSM
K.K. Gudima, S. Mashnik, A.J. Sierk
Los Alamos, December, 2001

DCM - Dubna Cascade Model
Monte-Carlo Generator of Heavy Ion Collisions DCM-SMM,
M. Baznat, A. Botvina, G. Musulmanbekov,
V. Toneev, V. Zhezher
Phys. Part. Nucl. Lett. 17 (2020) 3, 303

A.S. Botvina, K. K. Gudima, J.Steinheimer,
M. Bleicher, and J. Pochodzalla
Phys. Rev. C ***95****, 014902 (2017*)

We propose a possible explanation in QGS model.



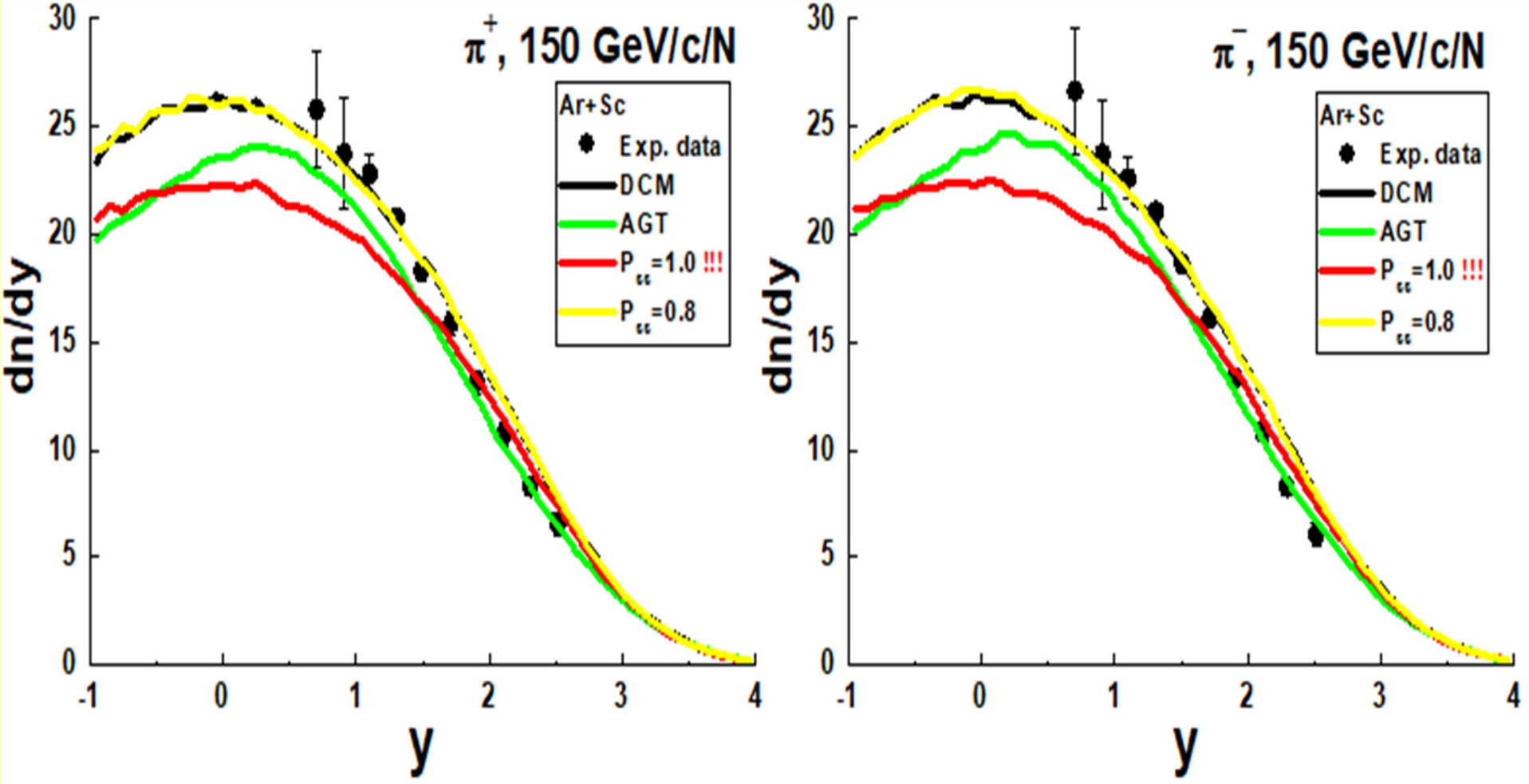
SUBROUTINE CHAINS Original code

```
IF(NAVAL.EQ.0) GO TO 2
      IF(NUAVAL.NE.IPAR) GO TO 1
      IAA=1
      NASEA=NASEA+1
      JS1=NASEA
      IFLAS(NASEA)=1+INT(RNDM(-1.)/PUD) ! PUD=0.42  ! Uzhi
      GO TO 3
  1   CONTINUE
2     NAVAL=NAVAL+1
```

Our changes

```
IF(NAVAL.EQ.0) GO TO 2
      IF(NUAVAL.NE.IPAR) GO TO 1
      IAA=1
      NASEA=NASEA+1
      JS1=NASEA
c       IFLAS(NASEA)=1+INT(RNDM(-1.)/PUD)    ! Uzhi
      IFLAS(NASEA)= 3                        ! Uzhi
GO TO 3
  1   CONTINUE
2     NAVAL=NAVAL+1
```

We propose a possible explanation in QGS model.
At the same time a problem with Pi+ and Pi- appeared.



Requiring a description of π± meson production, Ps-sbar has to be ~ 80 %
Too much!
It would be well to improve the DCM model!

Conclusions

1. The probability of strange quark-antiquark production from the vacuum has to be changed in DCM.
2. The main problem is an understanding of K+ and K- production mechanism in AA interactions!