Summary of Particle Production Yield Studies for Project-X Kaon Experiments

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OUTLINE

- LAQGSM Model in MARS15 Code
- Benchmarking of Kaon Yields for pp, pd and pC
- Total and Fractional Yields vs Beam Energy T_p for pp, pd and pC at $1.5 < T_p < 10$ GeV
- Momentum, Angular and Double-Differential Distributions for pp and pd at $T_p = 3$ and 8 GeV
- Summary

LAQGSM

LAQGSM is an improved version [1] of the time-dependent Dubna intranuclear Cascade Model, DCM [2], combined with isobar model at E < 4.5 GeV and Quark Gluon String Model (QGSM) [3] for elementary interactions inside nucleus at E > 4.5 GeV, coupled with Fermi breakup, coalescent and generalized evaporation-fission [4] models.

[1] S.G. Mashnik, K.K. Gudima, M.I. Baznat, A.J. Sierk, R.A. Prael, N.V. Mokhov, LANL Report, LA-UR-06-1764, Los-Alamos (2006).

[2] V.D. Toneev, K.K. Gudima, Nucl. Phys. A400 (1983) 173c.

[3] N.S. Amelin, K.K. Gudima, V.D. Toneev, Sov. J. Nucl. Phys. 51 (1990) 327; ibid. 51 (1990) 1730; ibid. 52 (1990) 172; N. S. Amelin, CERN/IT/ASD Report CERN/IT/99/6, Geneva, Switzerland (1999).

[4] S. Furihata, The GEM code users manual, NEA-1652 (2003).

LAQGSM in MARS15

The Los Alamos Quark-Gluon String Model code, **LAQGSM03.03**, has been enhanced over last several months in the intermediate 2 to 8 GeV region of interest for Project X experiments.

It is used in the MARS15 code for photon, hadron and heavy-ion projectiles at a few MeV/A to about a few TeV/A, providing a power of full theoretically consistent modeling of exclusive and inclusive distributions of secondary particles, spallation, fission, and fragmentation products in realistic experimental setups.

Production of K, Λ, and Σ in LAQGSM

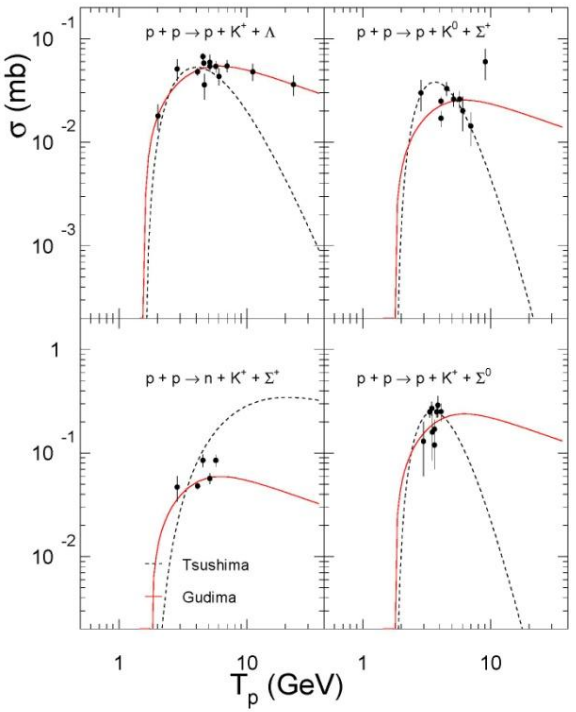
In the LAQGSM code K, Λ, and Σ are produced via the following channels:

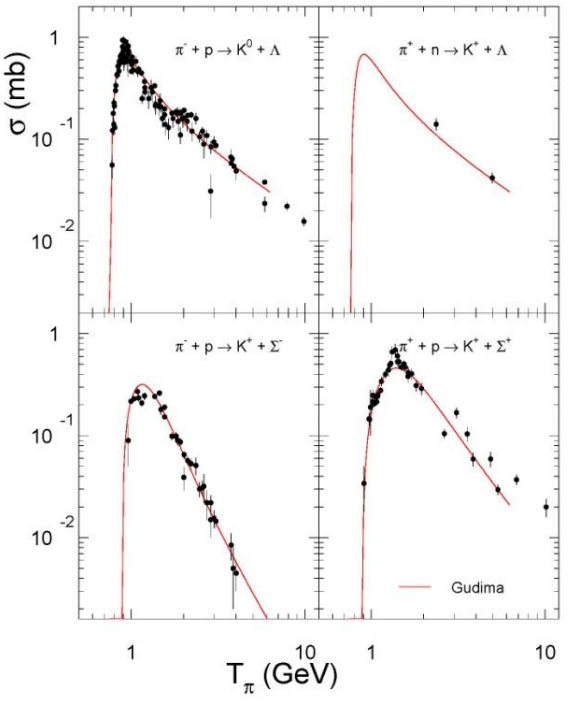
N+N→ K + Λ+ N , π + N → K + Λ, M+M →K + AK, π + Λ(Σ) → AK + N

N+N→ K + Σ + N , π + N → K + Σ, for intermediate energies ($s^{1/2}$ <4.5 GeV), and

B+B → K + Λ + X, M + B → K + Λ + X, B+B →K + AK + X,

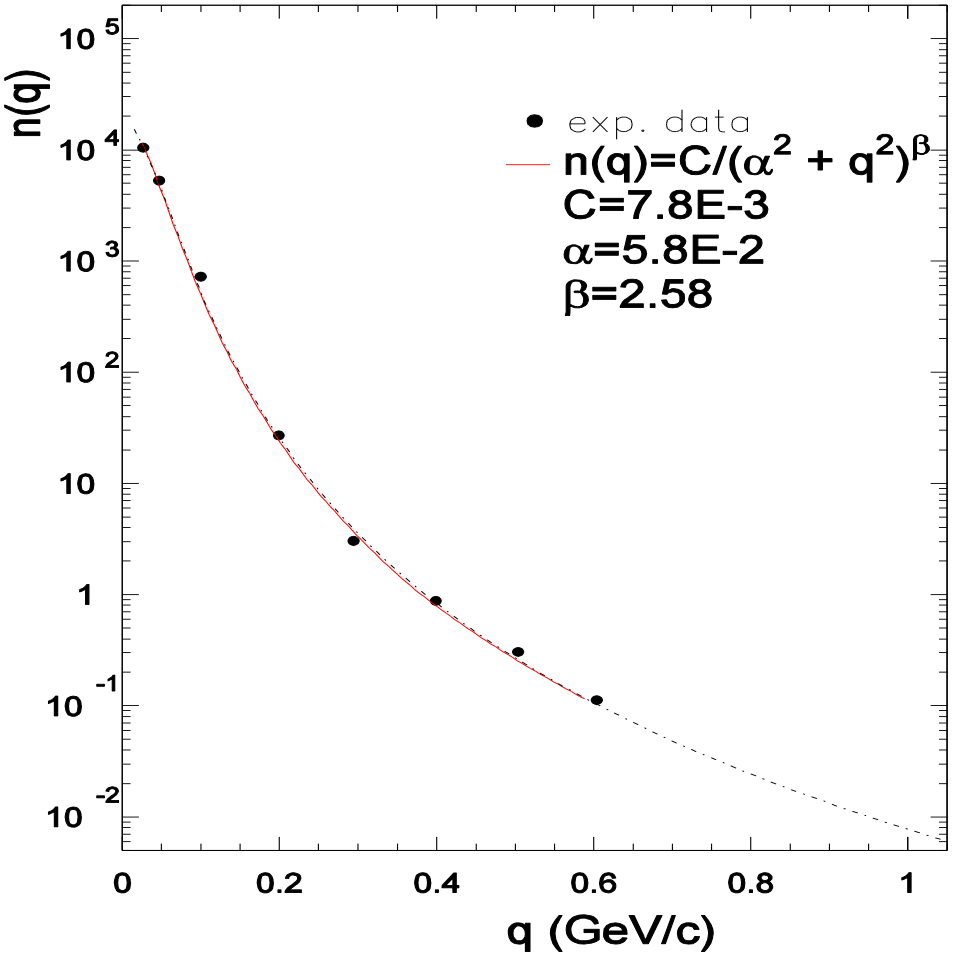
B+B → K + Σ + X, M + B → K + Σ + X, M+M →K + AK + X, for higher energies.



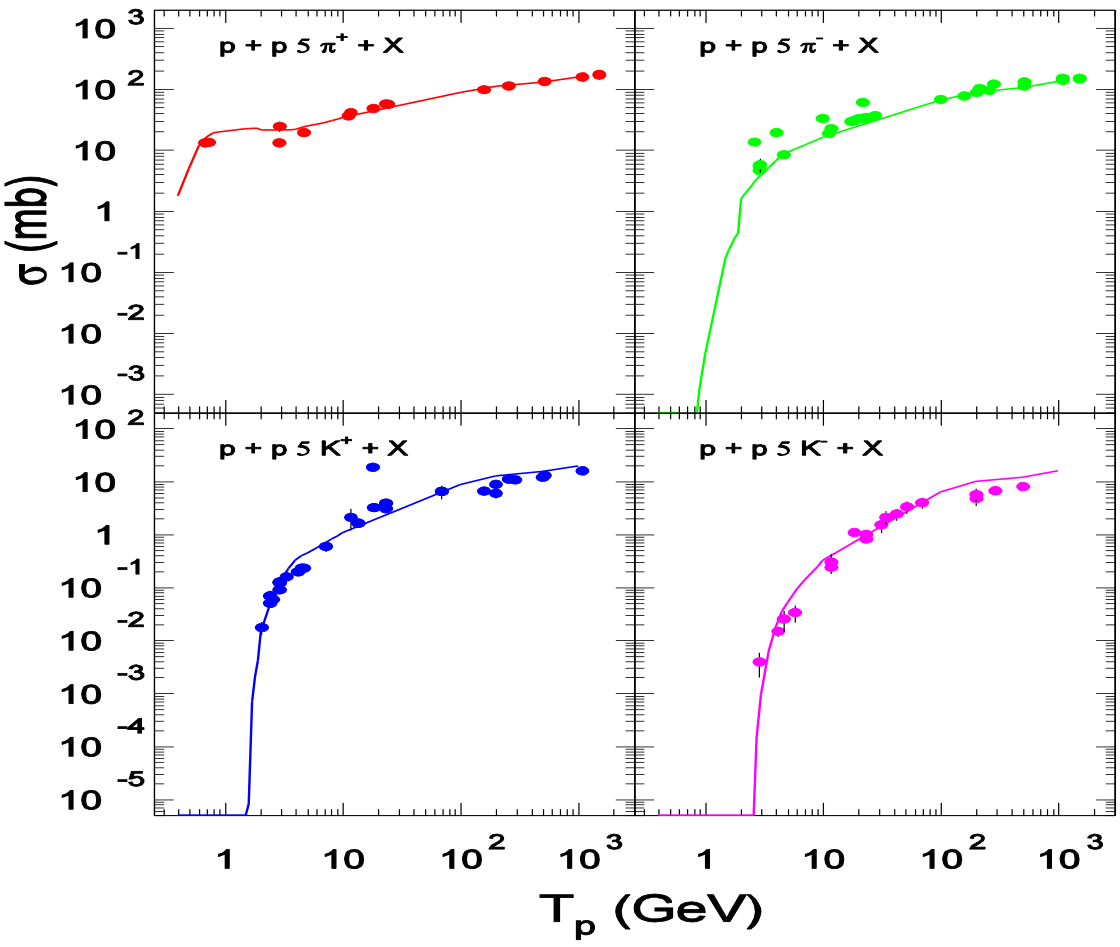


p + d Reaction in LAQGSM

Momentum distribution of nucleons inside deuteron:
$N(q)dq = Cq^2dq/[a^2 + q^2]^{\beta}$,
fitting experimental data
Phys. Rev. C65 (2002) 024306

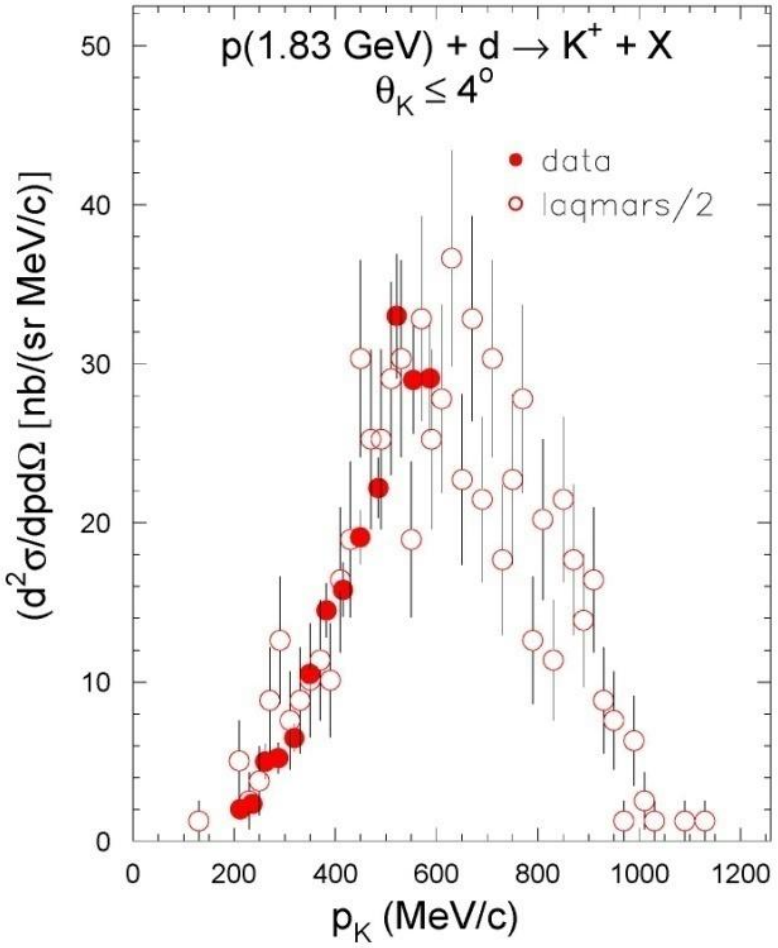


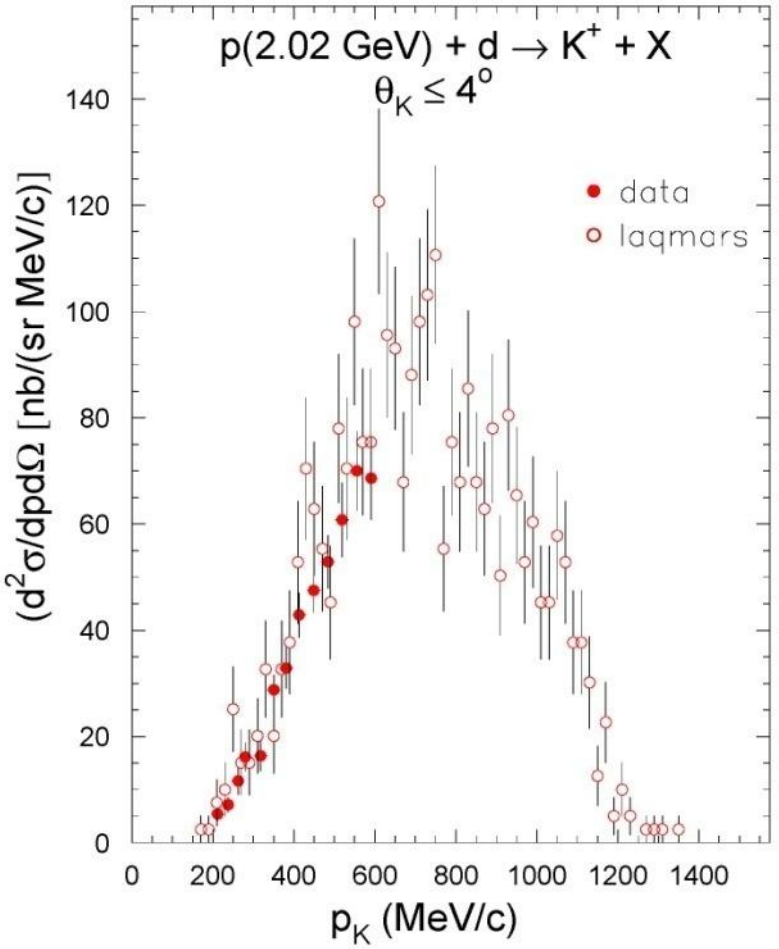
Benchmarking: Production xsec for p + p



Benchmarking: pd -> K^+ X at 1.83 & 2.02 GeV

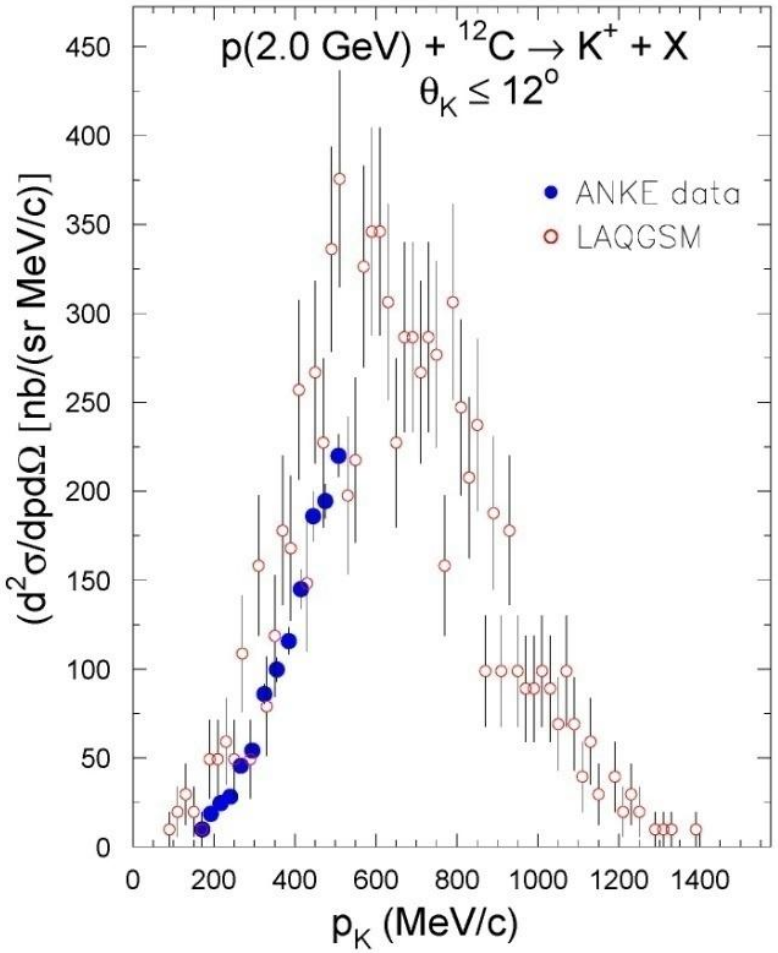
$\theta < 4$ deg

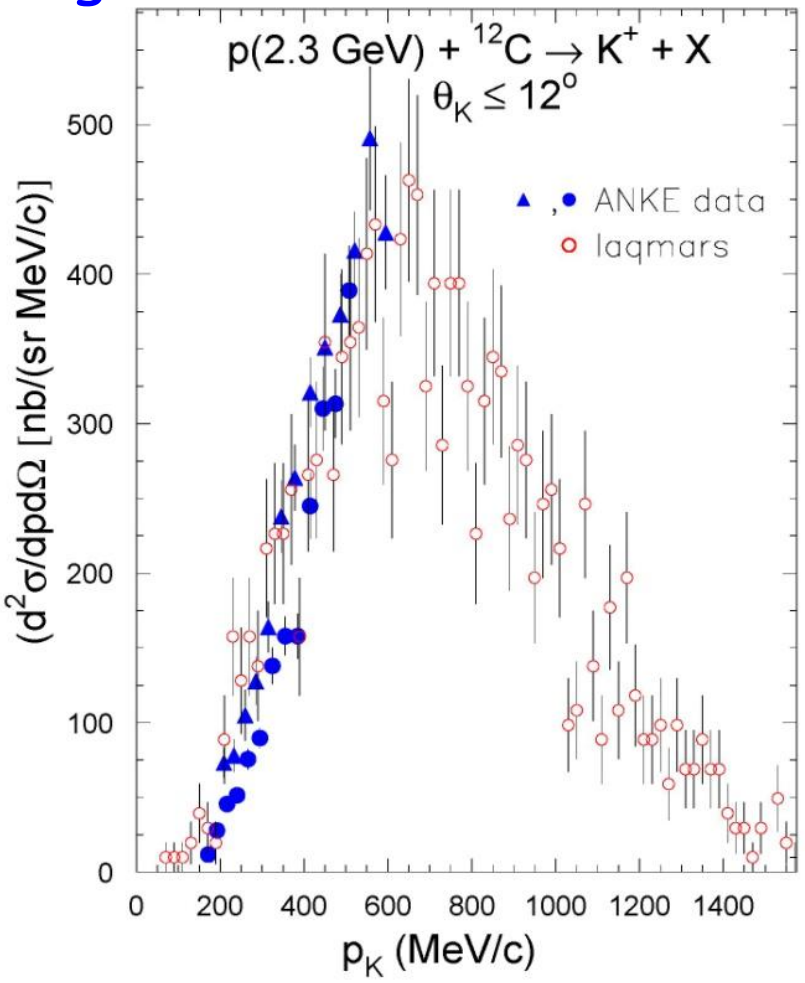




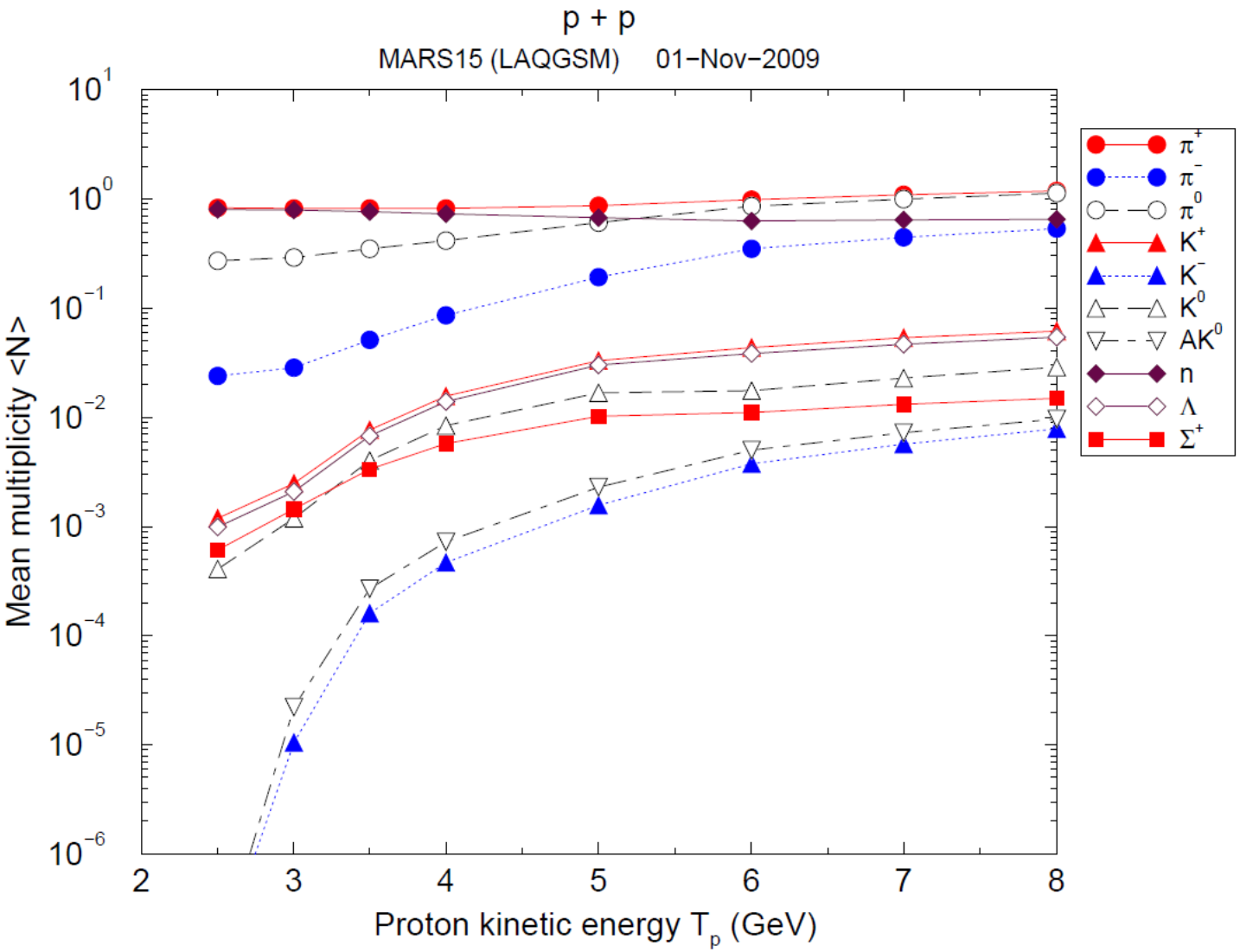
Benchmarking: pC -> K^+ X at 2 & 2.3 GeV

θ < 12 deg

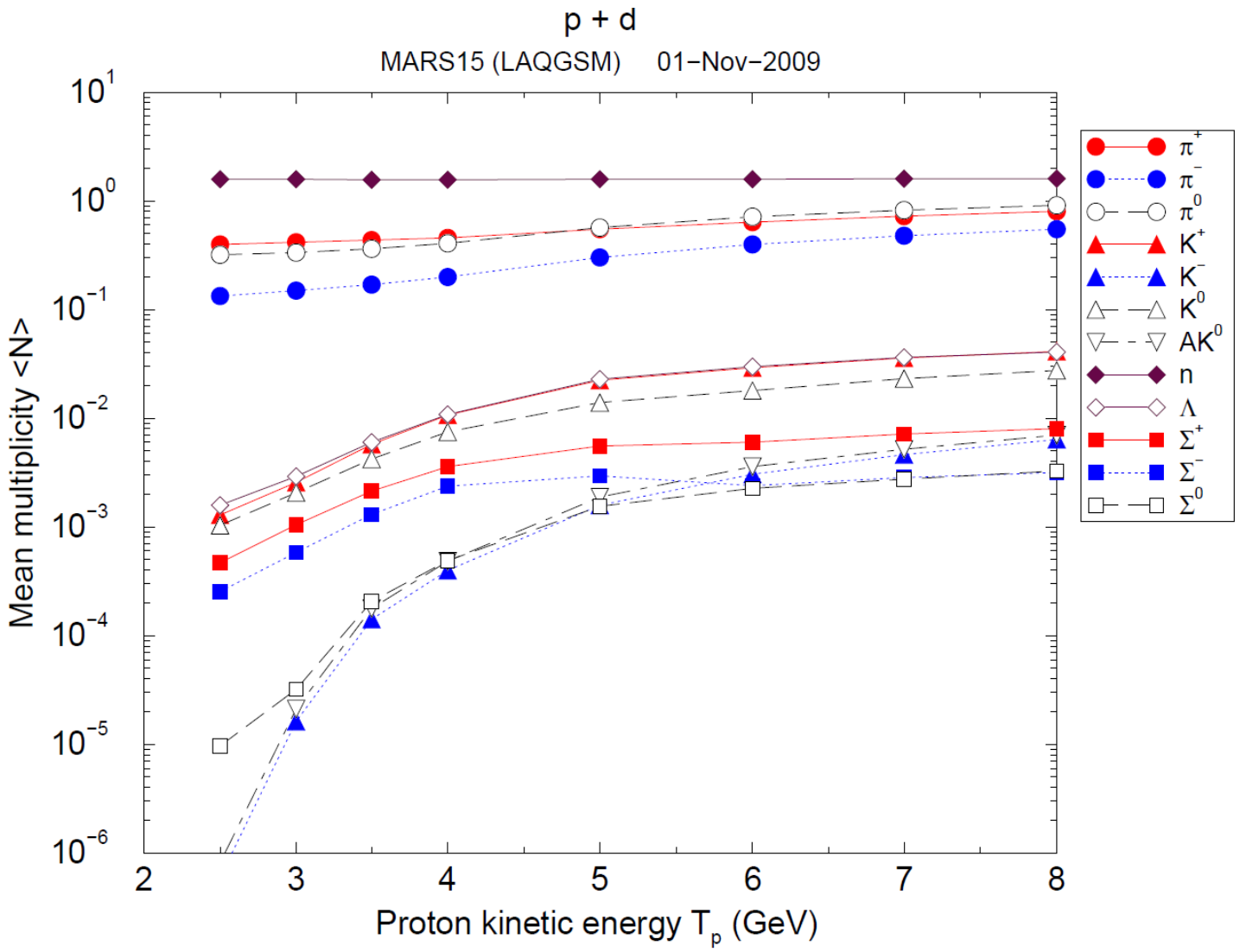




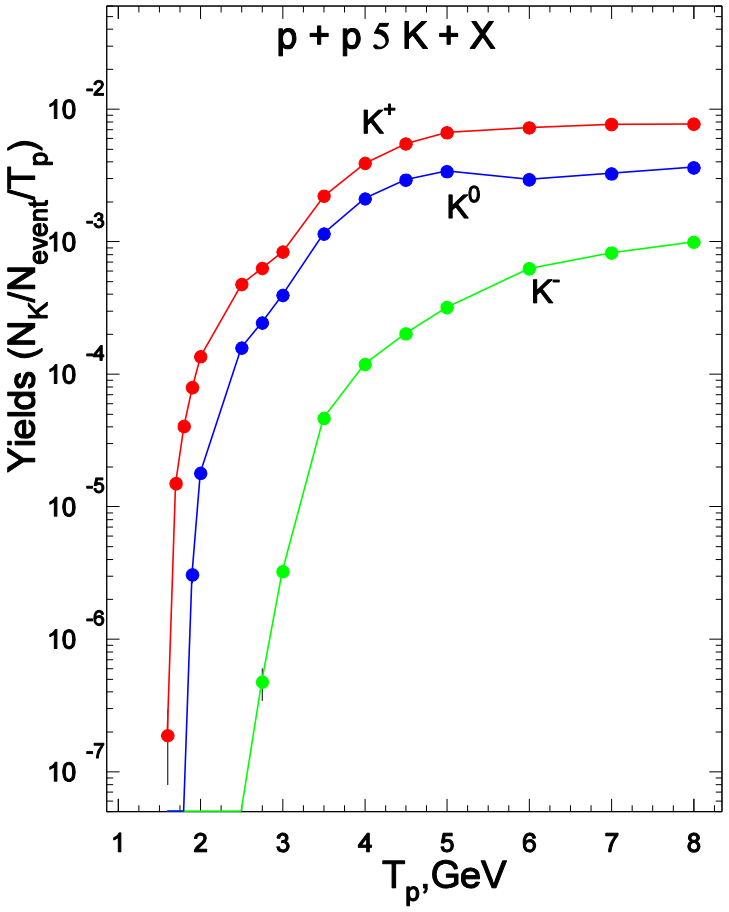
Mean Multiplicity for pp

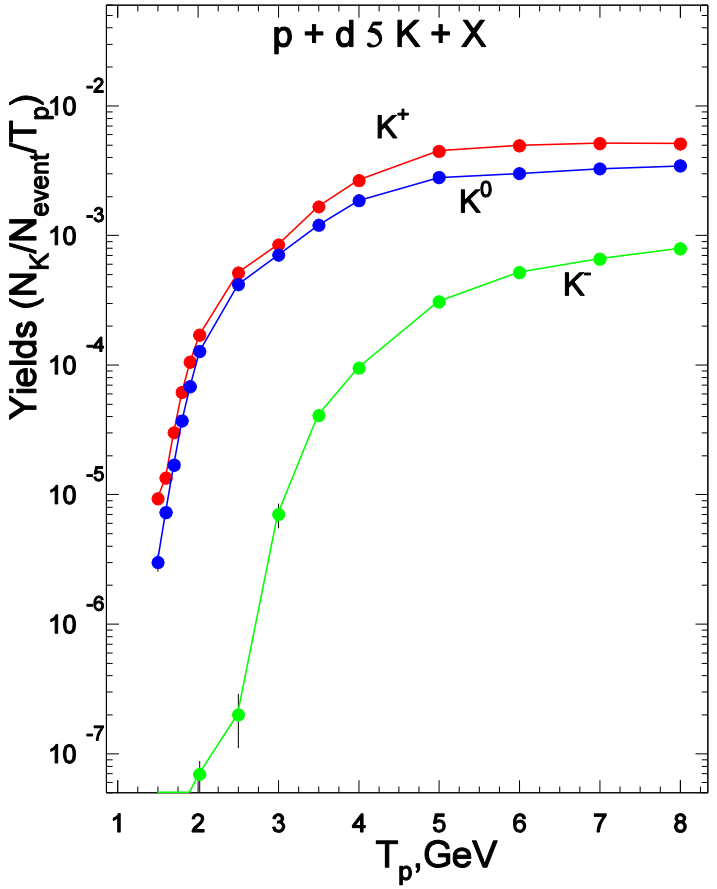


Mean Multiplicity for pd

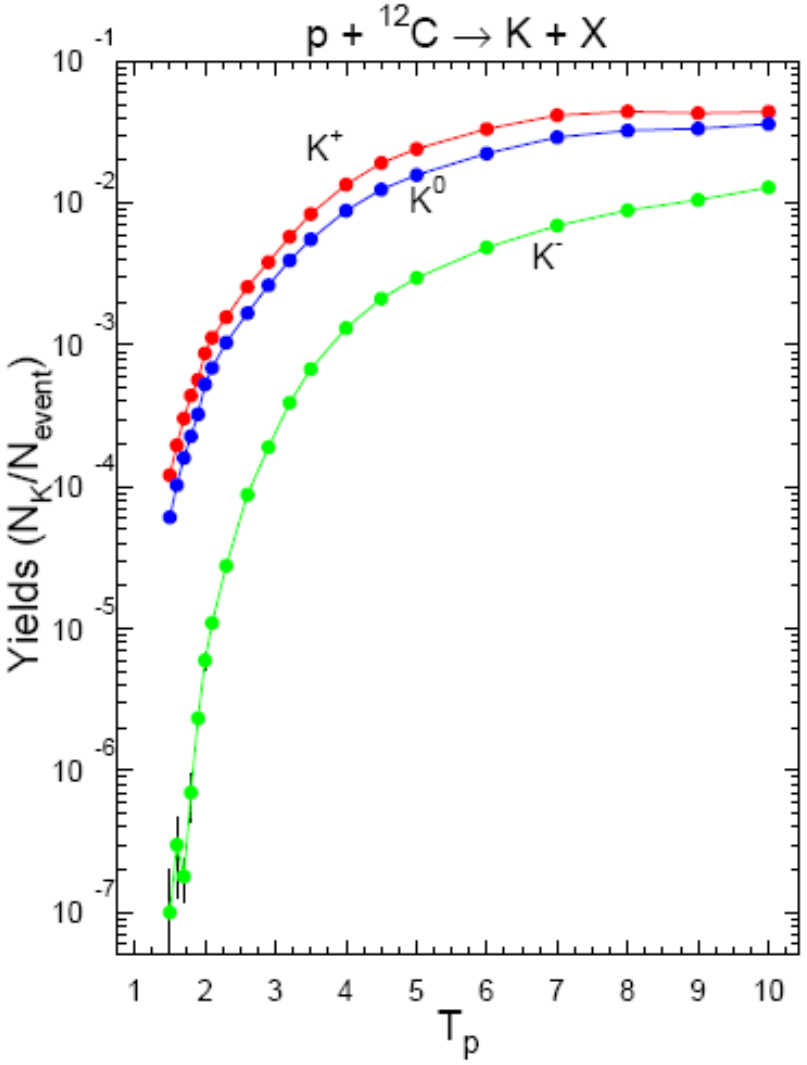


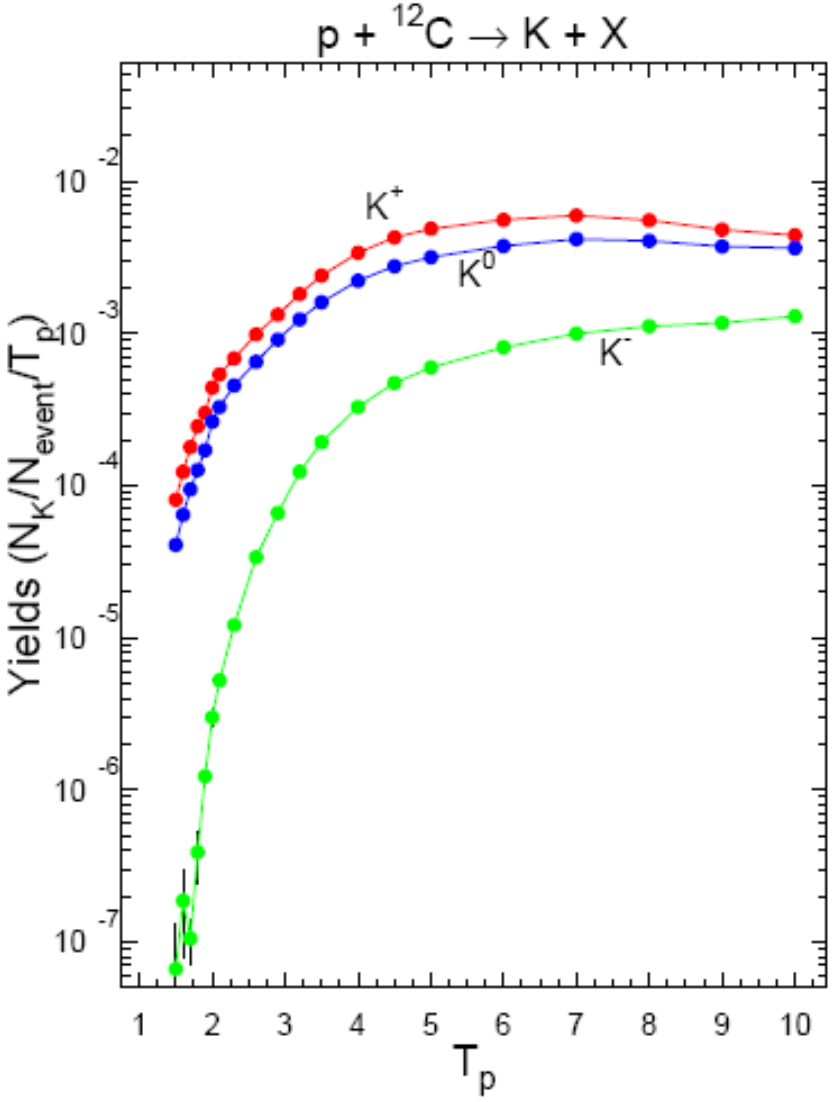
Kaon Yield per Proton Energy in pp and pd



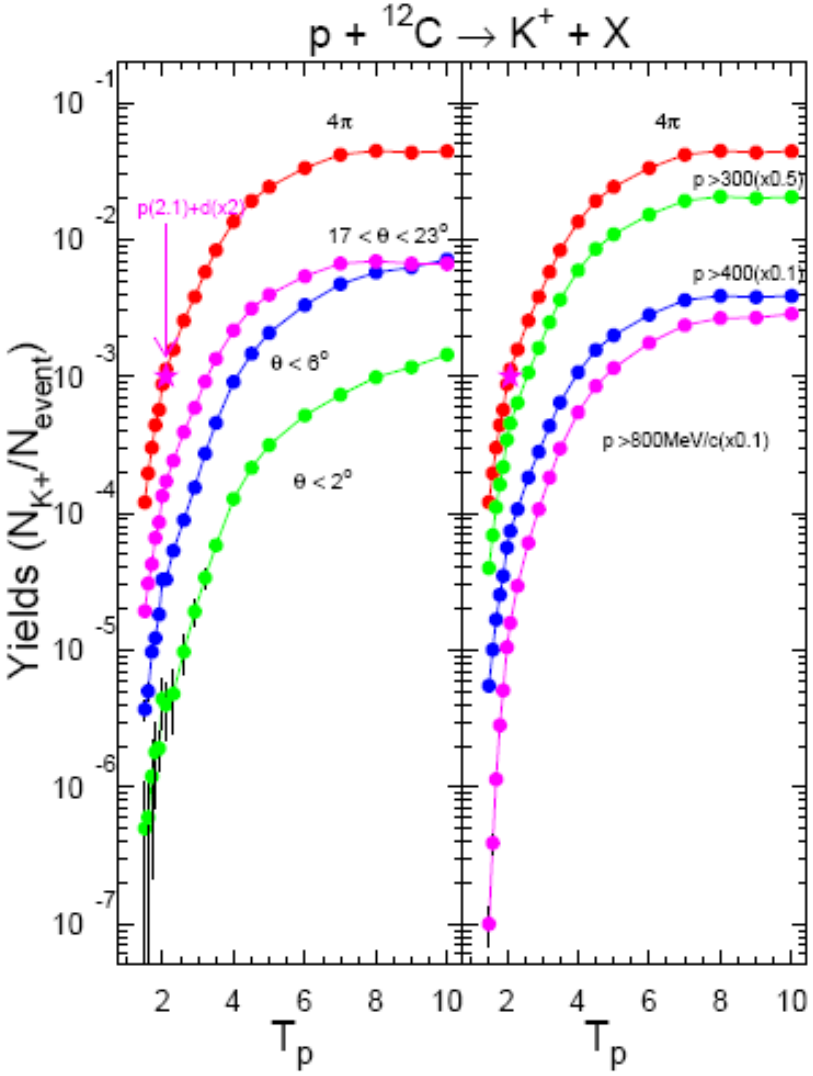


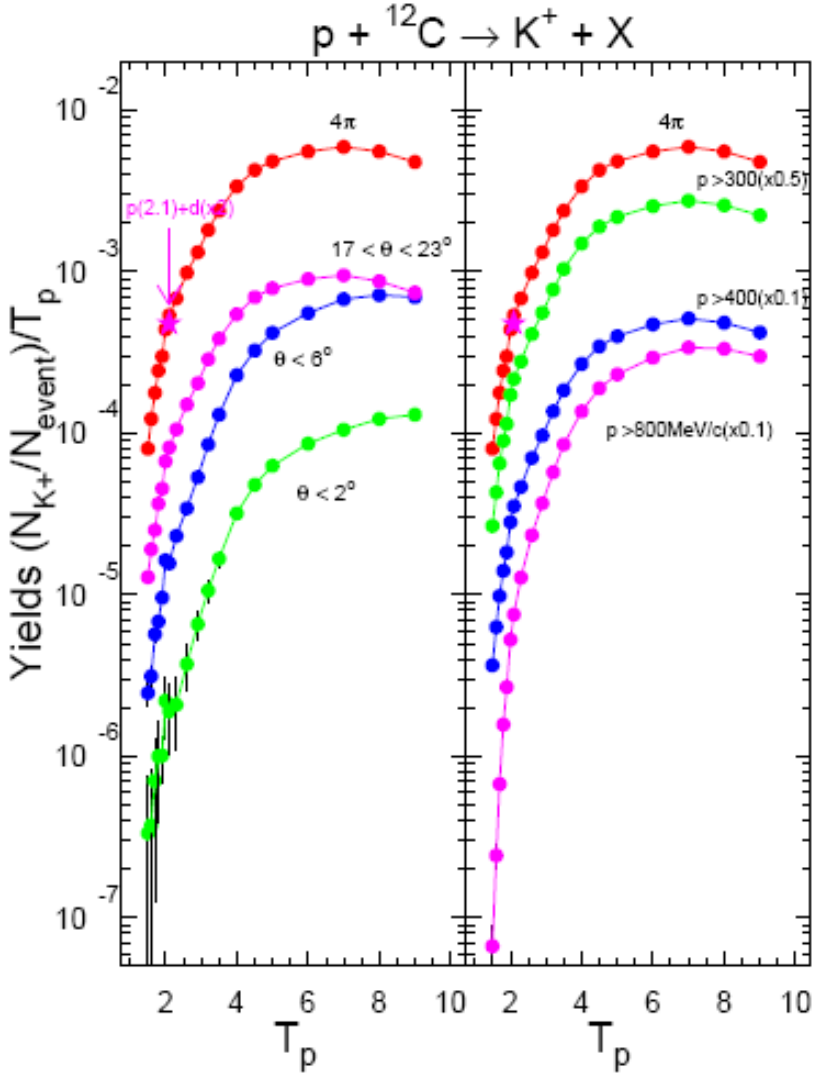
Kaon Yield and that per Proton Energy in pC



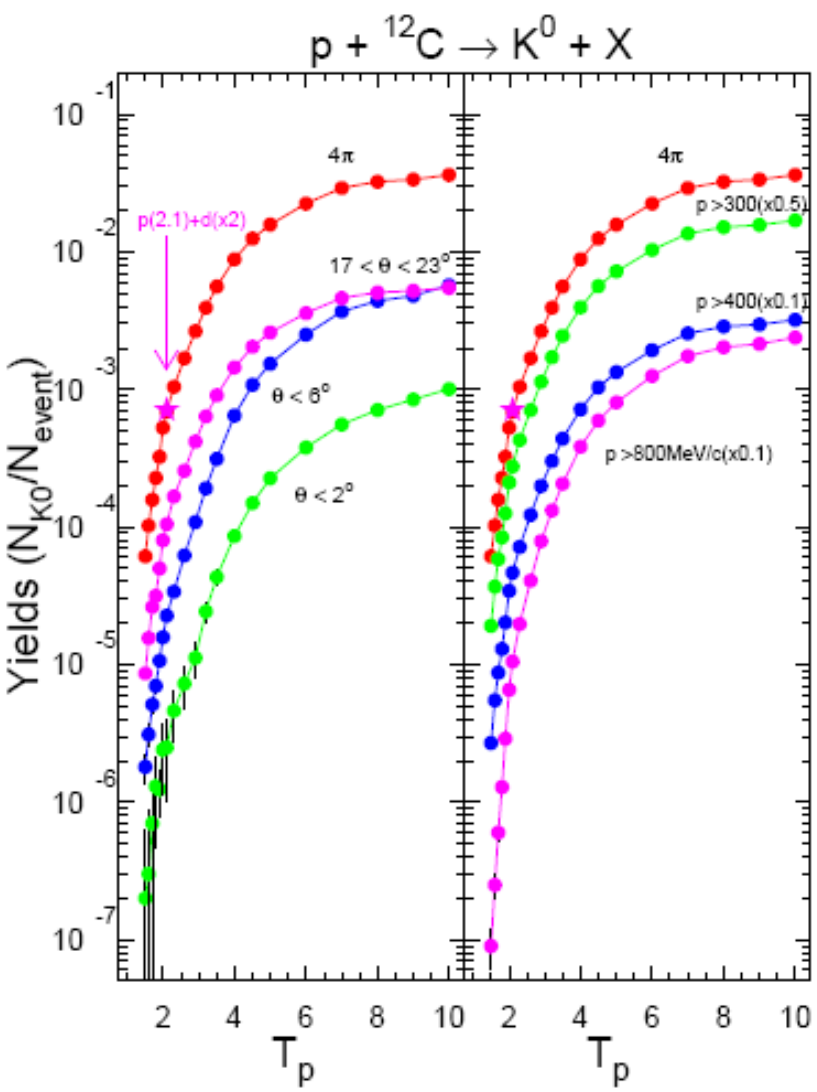


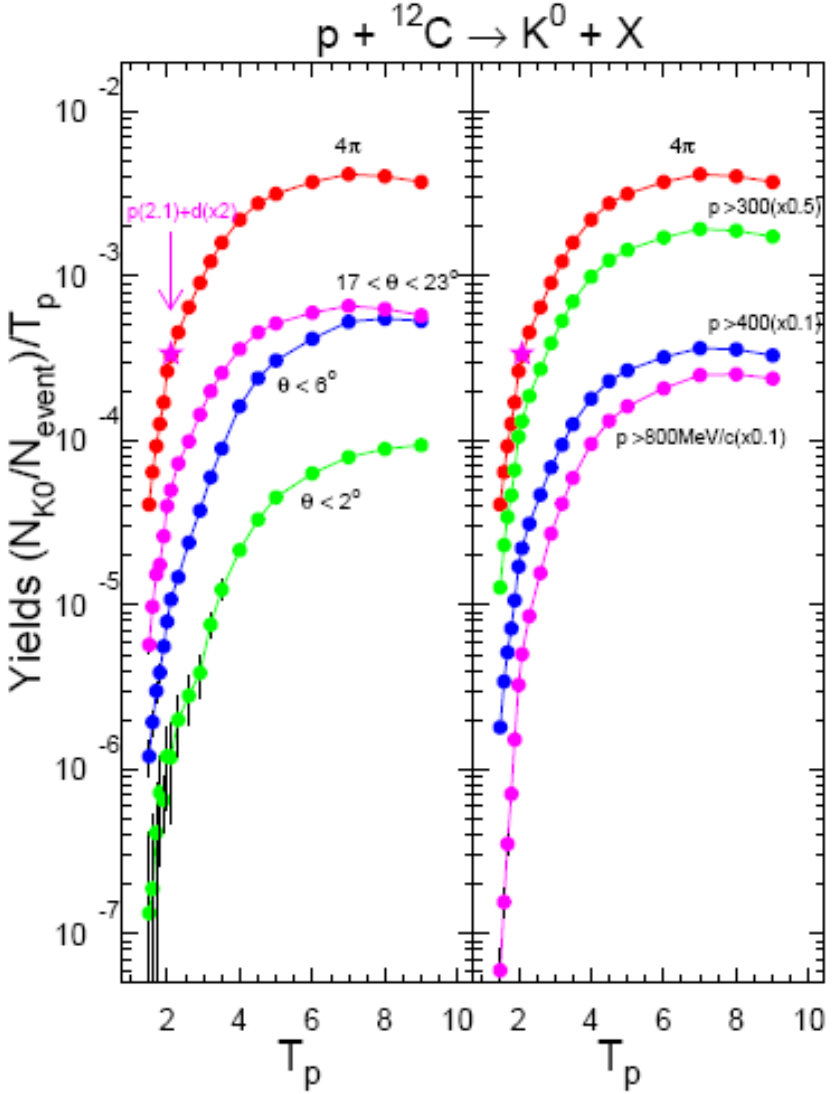
K^+ Yield in pC in Various Kinematical Regions



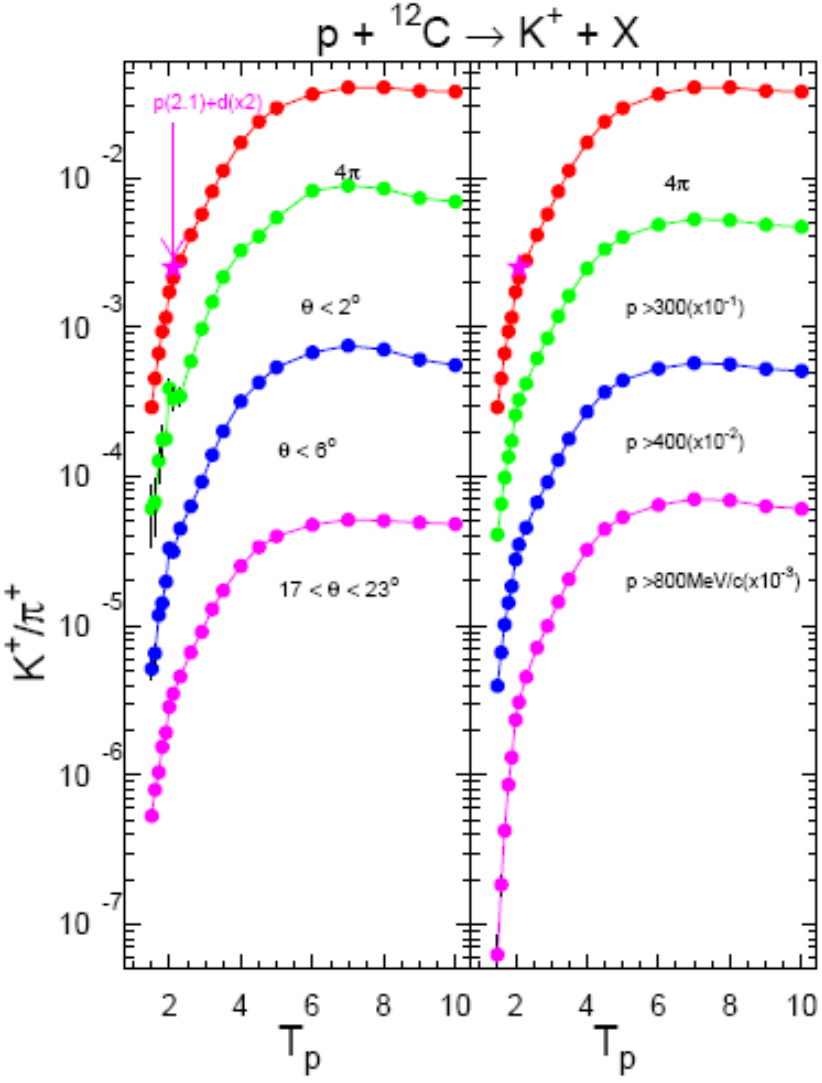


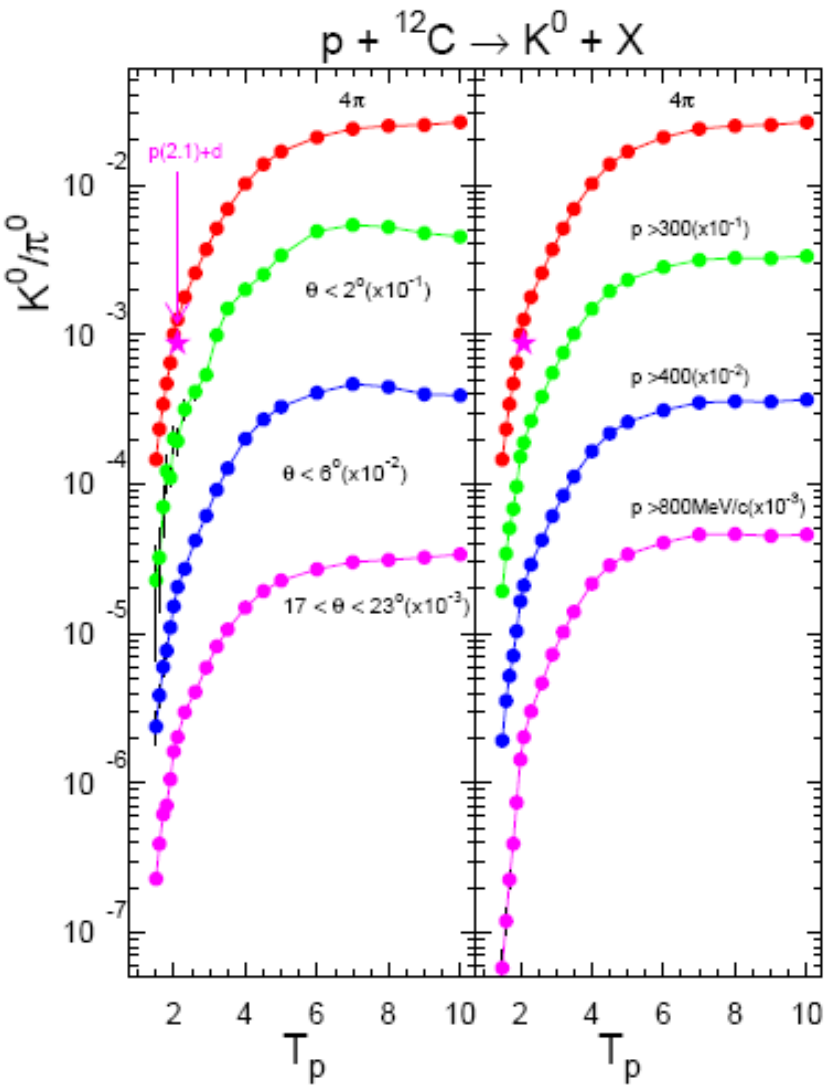
K^0 Yield in pC in Various Kinematical Regions



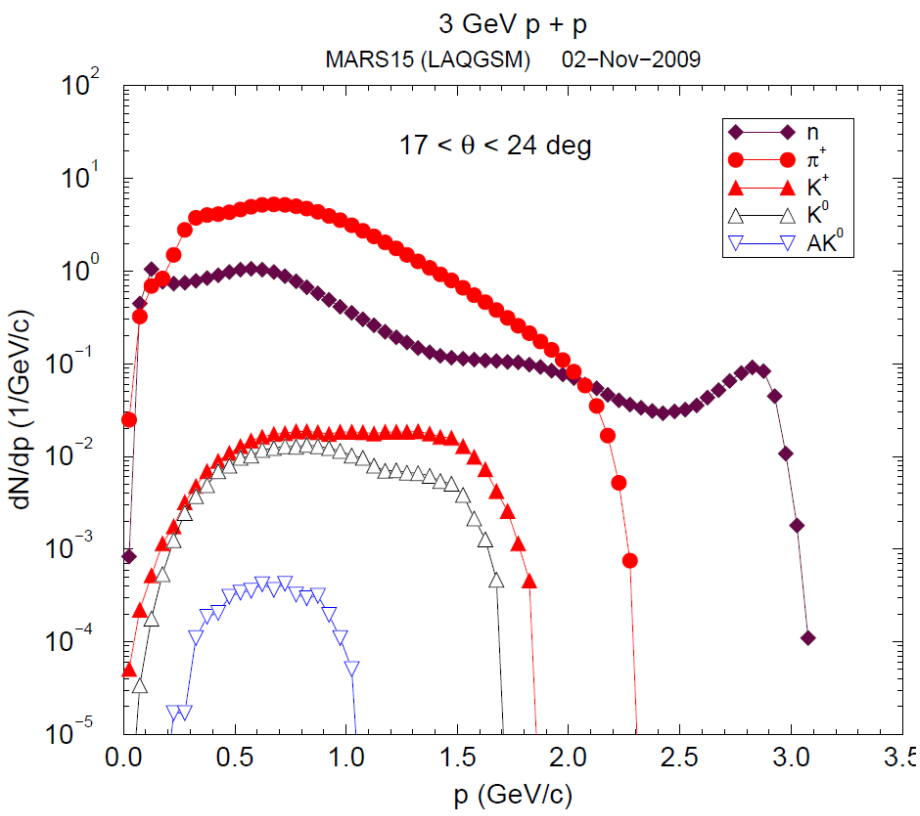


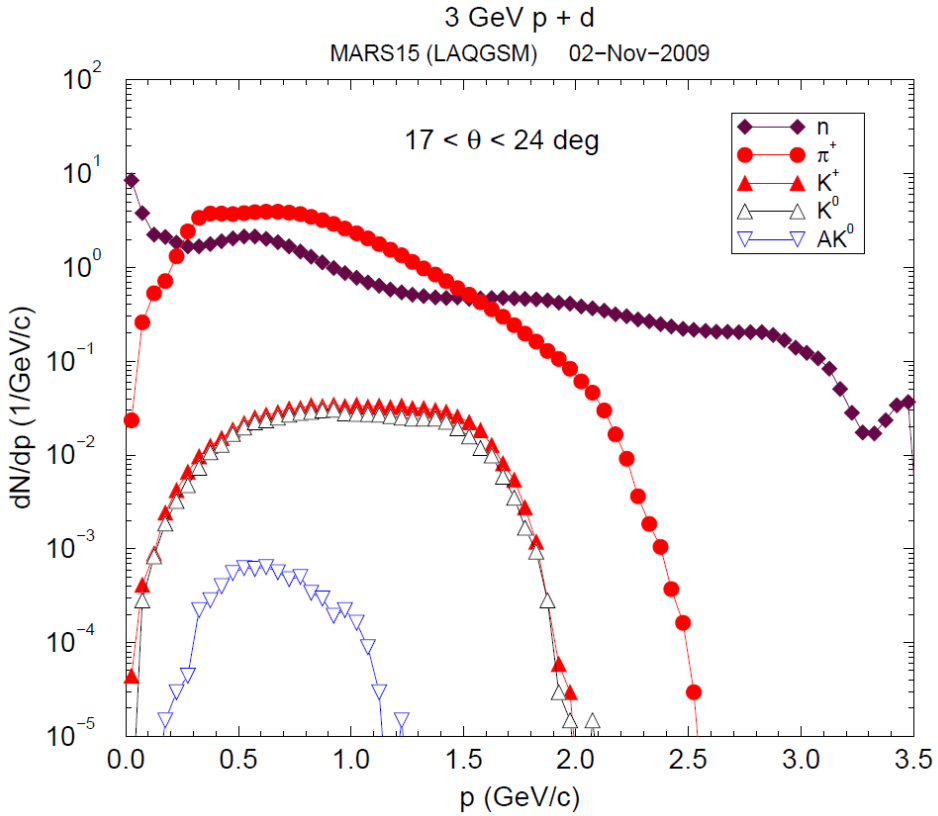
K/π Ratio in pC in Various Kinematical Regions





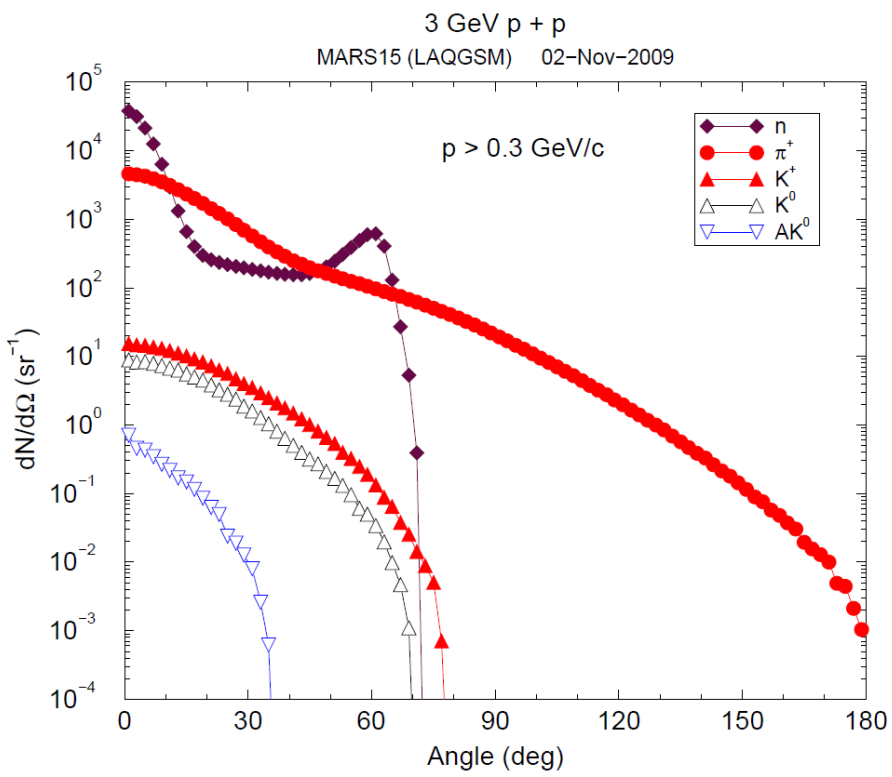
Momentum Spectra in pp and pd at 3 GeV

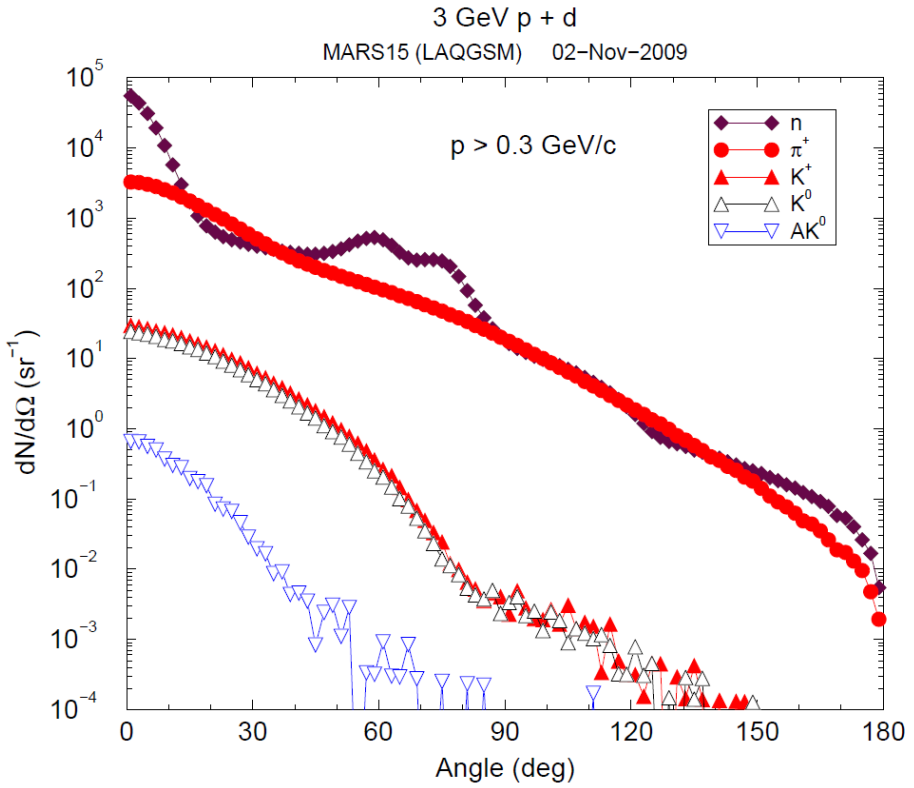




17 < θ < 24 deg

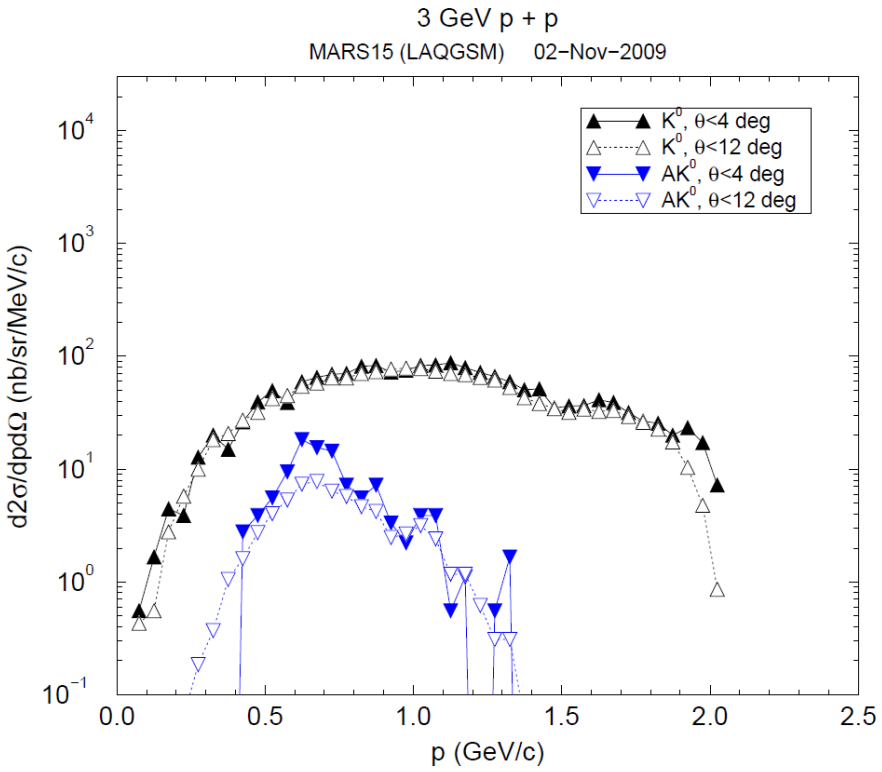
Angular Distributions in pp and pd at 3 GeV

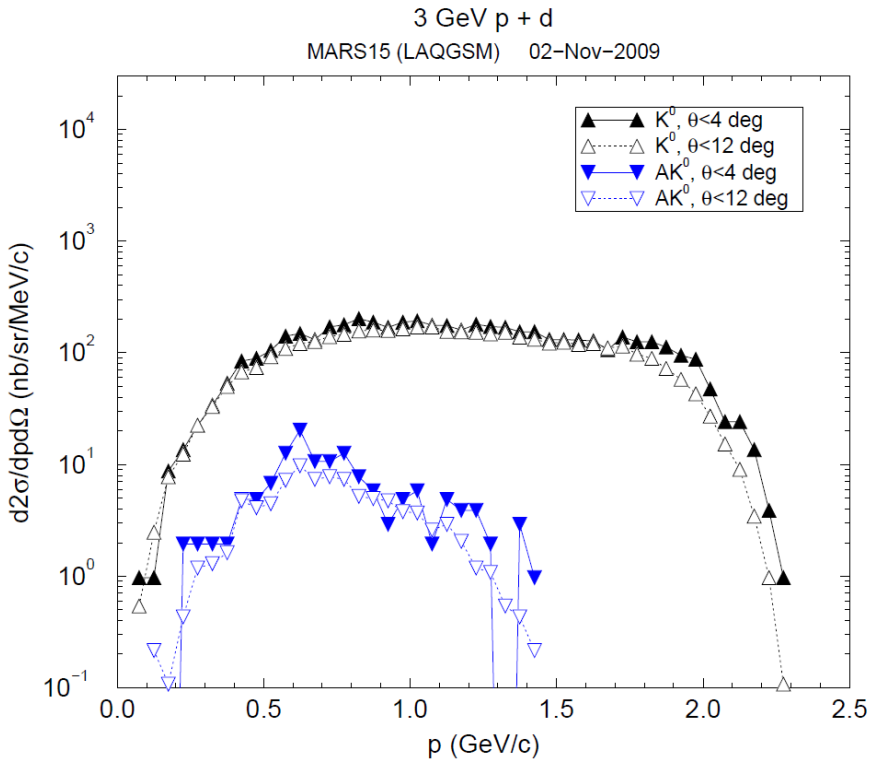




P > 0.3 GeV/c

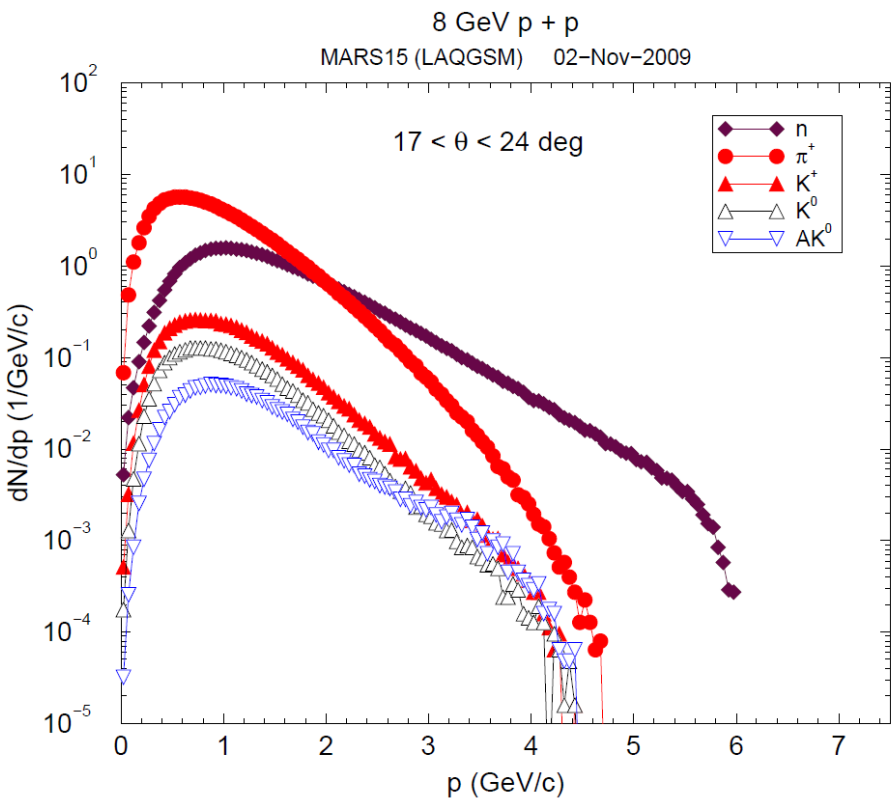
Neutral Kaon Double-Differential Cross-Sections in pp and pd at 3 GeV

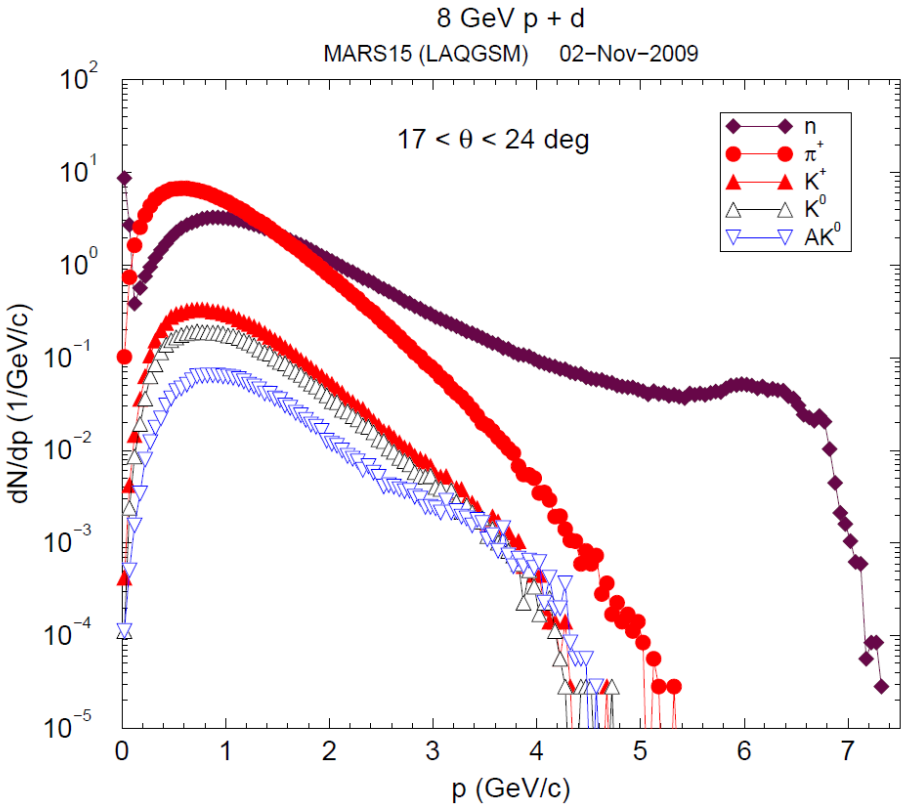




θ < 4 deg and θ < 12 deg

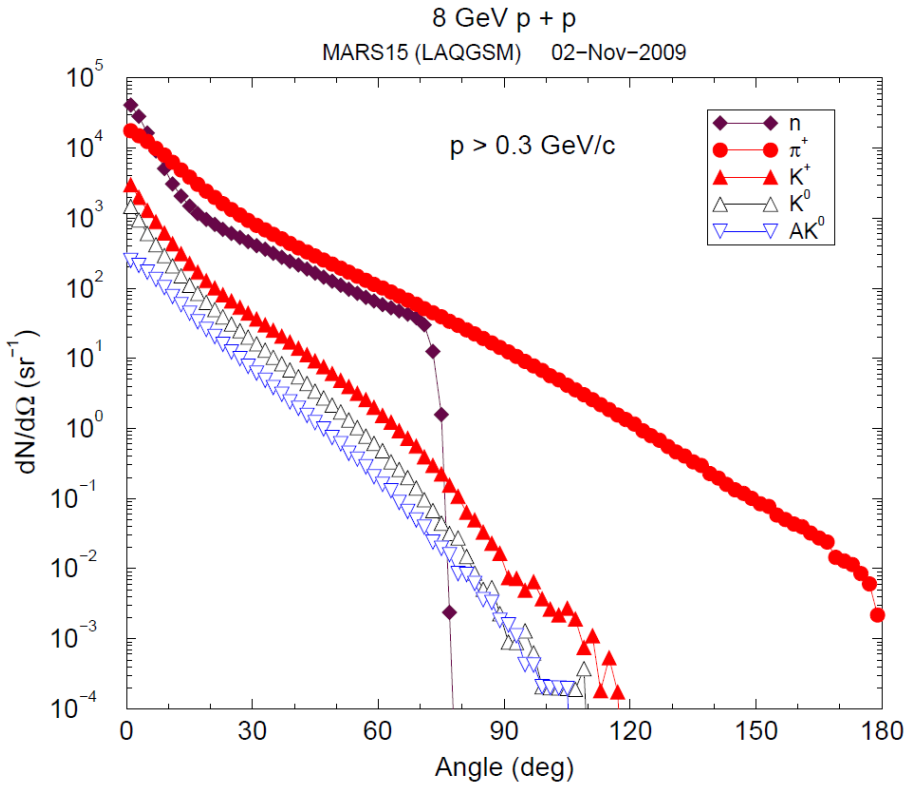
Momentum Spectra in pp and pd at 8 GeV

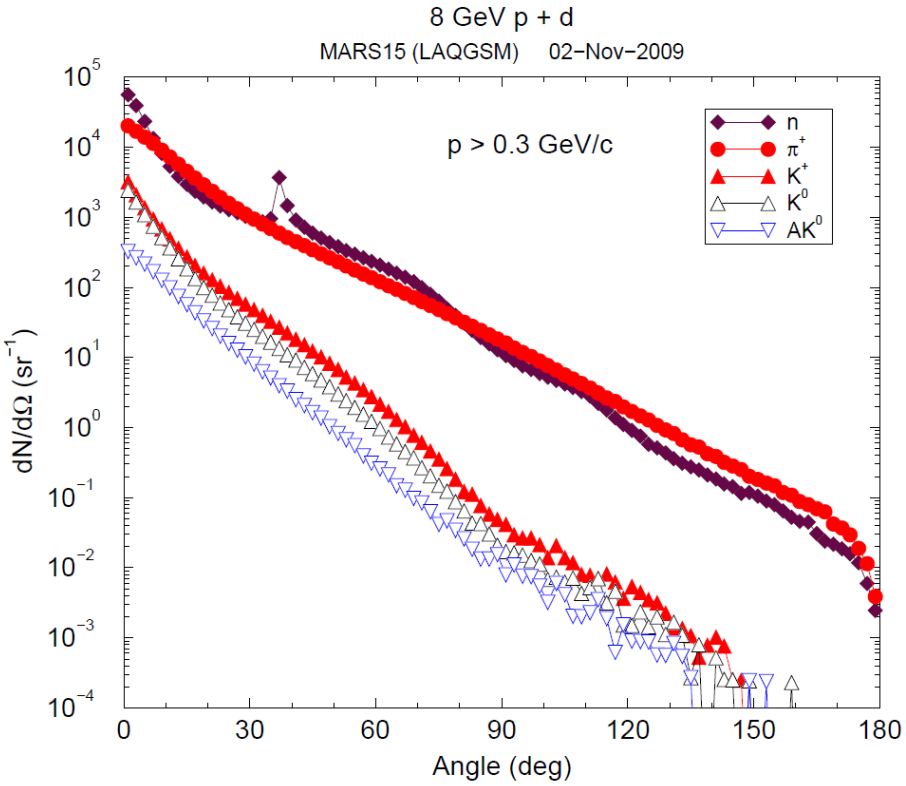




17 < θ < 24 deg

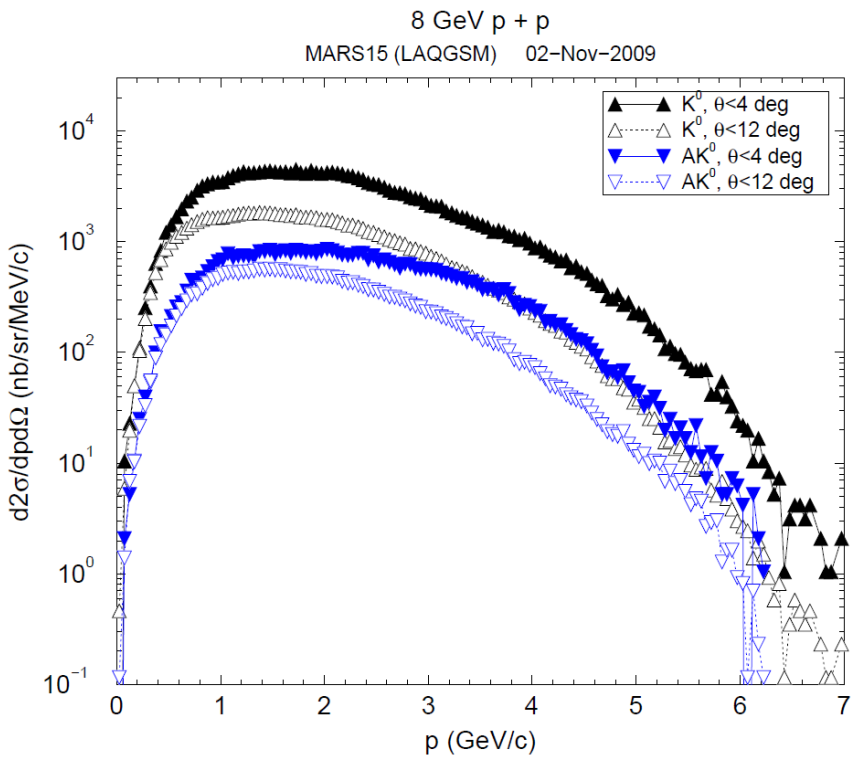
Angular Distributions in pp and pd at 8 GeV

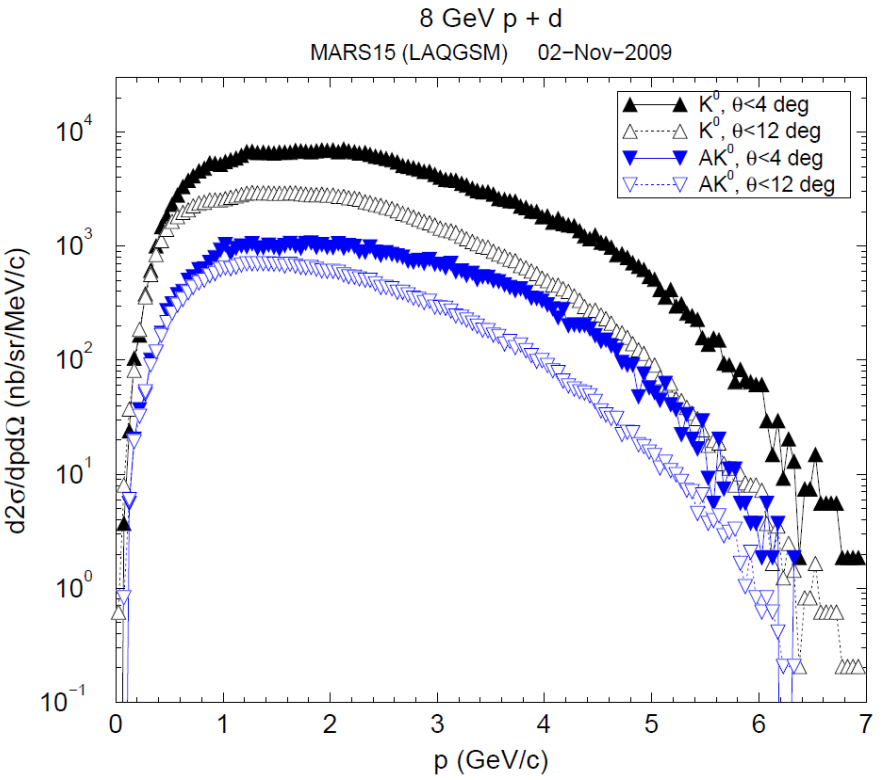




P > 0.3 GeV/c

Neutral Kaon Double-Differential Cross-Sections in pp and pd at 8 GeV





θ < 4 deg and θ < 12 deg

Summary

- LAQGSM09 model has recently been enhanced, benchmarked and updated in MARS15 at $1 < T_p < 8$ GeV with a focus on consistent particle production description for:
  - Kaon, hyperon and nucleon production on hydrogen, deuterium and other light nuclei in a near-threshold region.
  - Pion production at $0.1 < p < 0.3$ GeV/c on high-Z nuclei (Neutrino Factory and Muon Collider).
  - Pion production at $T < 40$ MeV on high-Z nuclei for (Mu2e).
- K^+/T_p and K^0/T_p on low-Z targets are almost energy-independent at $T_p \geq 4$ GeV, reaching a broad maximum at 6-7 GeV, same for K/π ratio; K^-/T_p and AK^0/T_p are practically independent of Tp at $Tp \geq 6$ GeV. Accelerator, targetry and collection constraints need to be taken into account while choosing beam energy at $Tp \geq 4$ GeV.
- First runs with MARS15 (LAQGSM09) have been performed for realistic thick targets and capture systems.