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Kaon Yield Studies for Proton Driver Beams of 2-8 GeV Kinetic Energy

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WG1 : SRF Linac for Neutrino, Muon and Kaon Physics

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LAQGSM in MARS15

The Los Alamos Quark-Gluon String Model code, **LAQGSM03.03 (2007)**, is implemented into MARS15 for photon, hadron and heavy-ion projectiles at a few MeV/A to about a few TeV/A.

This provides a power of full theoretically consistent modeling of exclusive and inclusive distributions of secondary particles, spallation, fission, and fragmentation products.

The LAQGSM Code

The INC stage of reactions is described by LAQGSM with a recently improved version [1] of the time dependent intranuclear cascade model developed initially in Dubna, often referred in literature simply as the Dubna intranuclear Cascade Model, DCM[2], using the Quark-Gluon String Model (QGSM) [3]to describe elementary interactions at energies above 4.5 GeV.

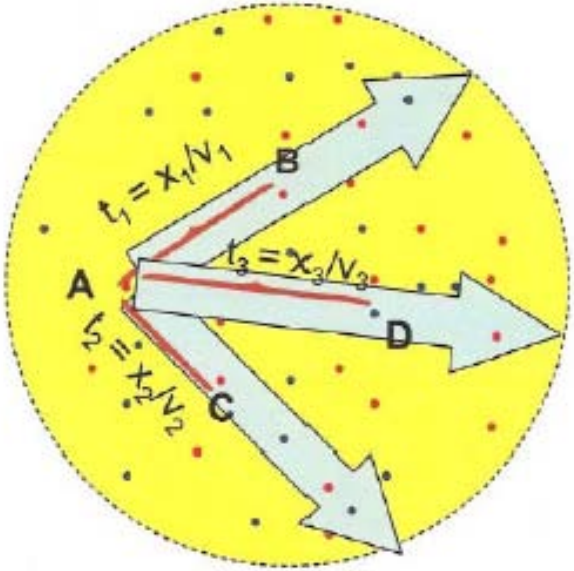
[1] S.G. Mashnik, K.K. Gudima, M.I. Baznat, A.J. Sierk, R.A. Prael, N.V. Mokhov, LANL Report, LA-UR-06-1764, Los-Alamos (2006).

[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).

The LAQGSM Code

Formation time and trailing effect are used in time evolution of cascade :



$t^f_{1(2,3,...)}$ is the formation time of the cascade particle #1(2,3,…)
If $t_2 < t_1$, $t_2 < t_3$,…, and $t_2 > t^f_2$, particle #2 interacts first in point **C**
IntraNuclear nucleons involved in interactions become "cascade" particles and are removed from the status of "frozen" target nucleons (trailing effect)

The formation time: $t^f = (E/m)t_f^0$; $t_f^0 = C_t\ \hbar/m_\pi$;
C_t = 1.0 for mesons and ~0.0 for baryons

Production of K, L, and Σ in LAQGSM

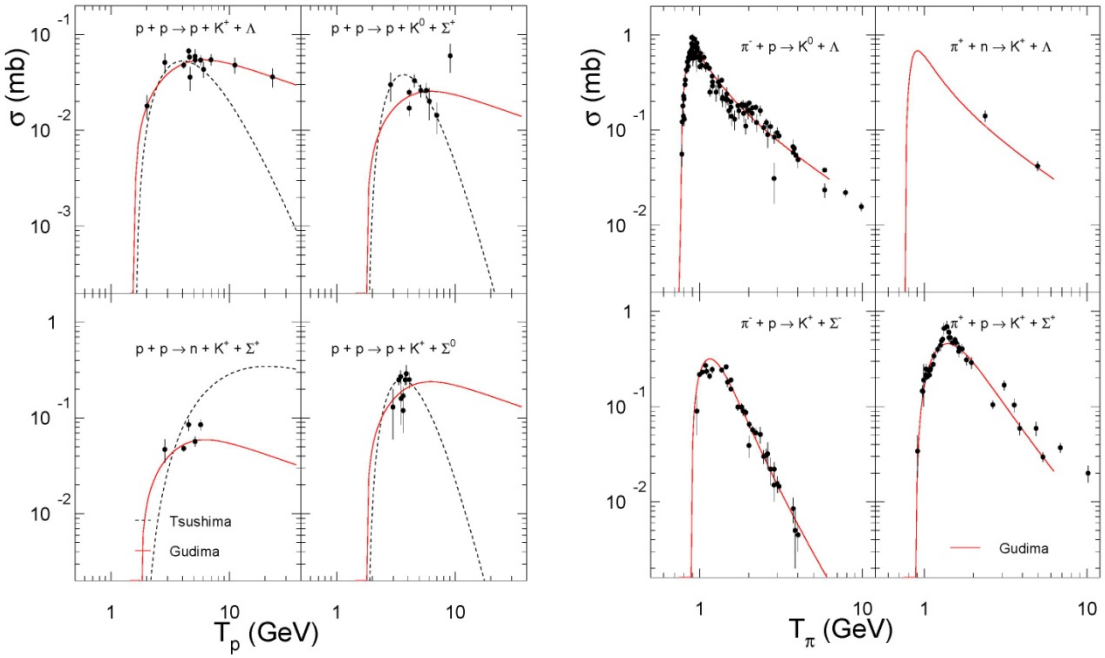
In the LAQGSM code K, L, and Σ are produced by channels:

N+N→ K + L+ N , π + N → K + L, M+M →K + AK, π + L(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 + L + X, M + B → K + L + X, B+B →K + AK + X,

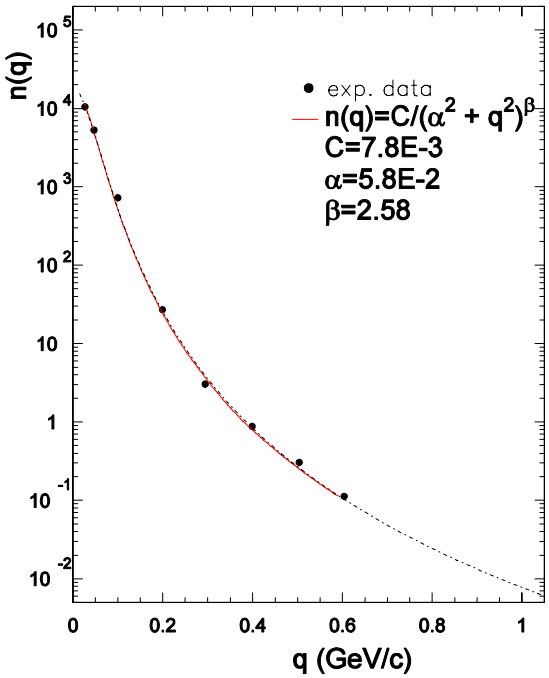
B+B → K + Σ + X, M + B → K + Σ + X, M+M →K + AK + X, for higher energies.

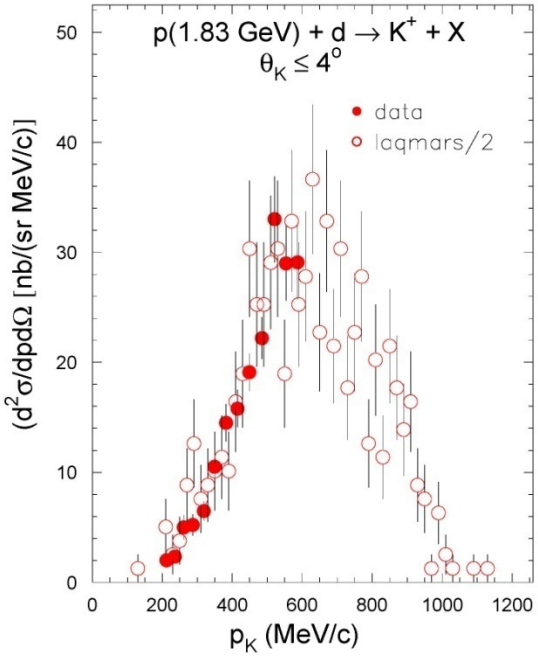


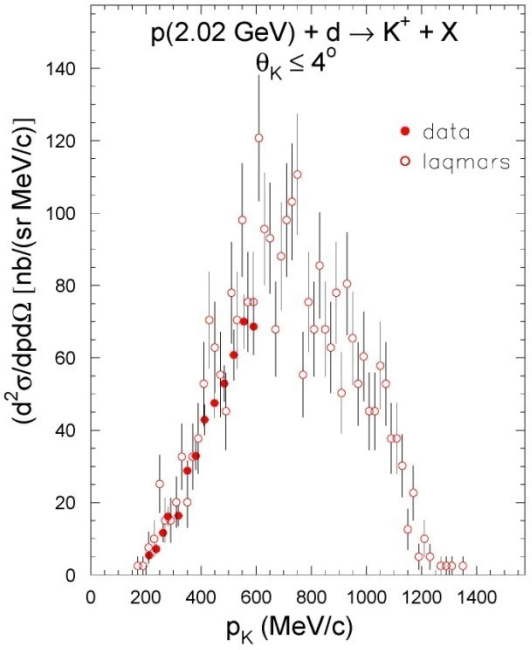
p + d reaction in LAQGSM

Momentum distribution of nucleons inside of deuteron is used in the form:

$N(q)dq = Cq^2dq/[a^2 + q^2]^{\beta}$, which results from fitting of experimental data (Phys. Rev. C65 (2002) 024306):

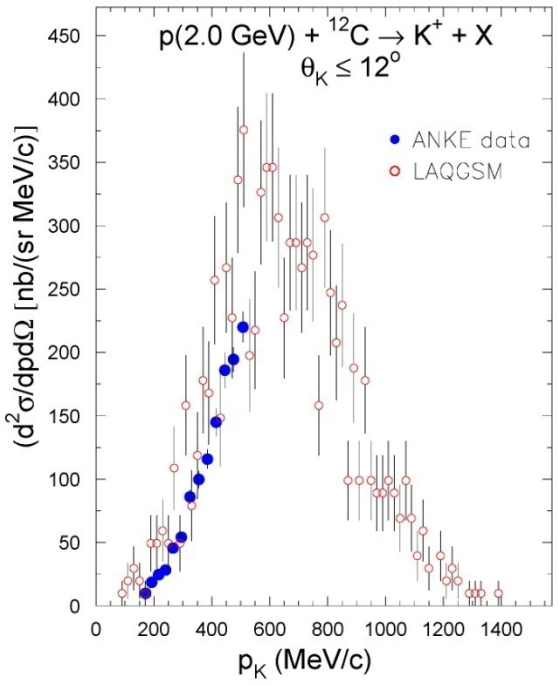


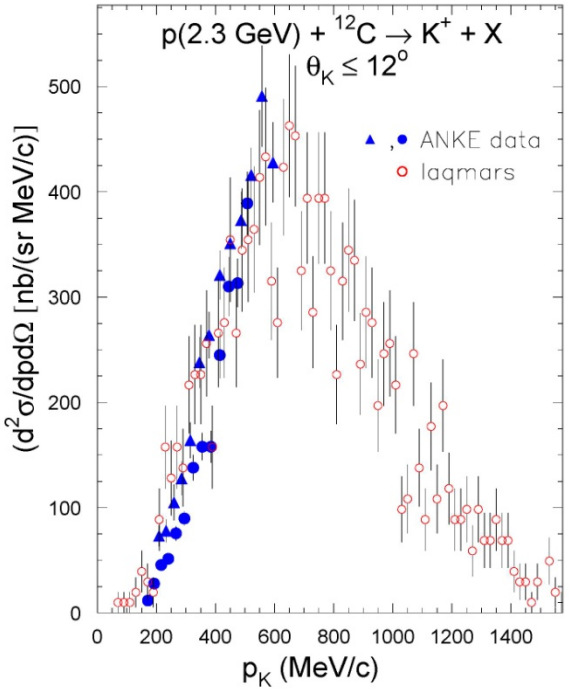




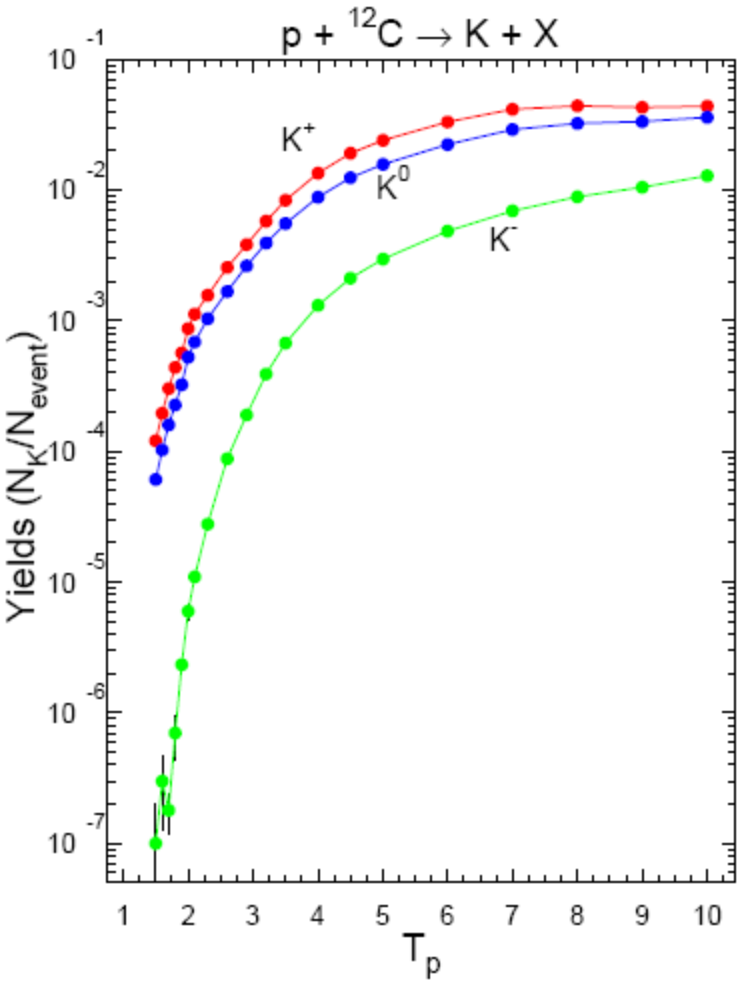
P + C reaction: Benchmarking.

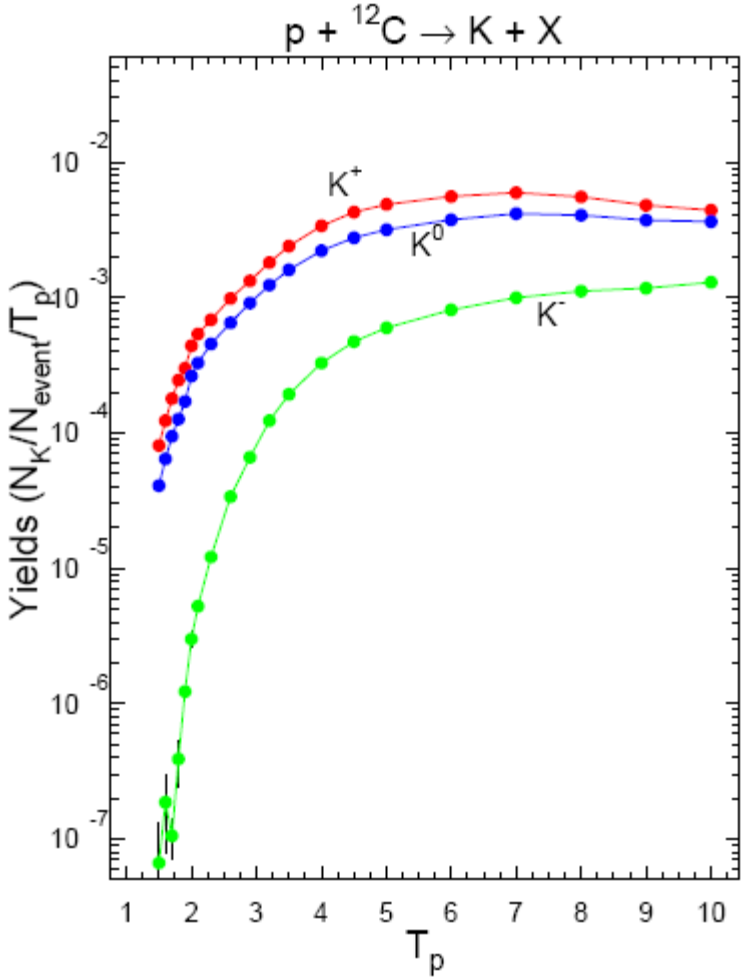
In the LAQGSM code all production cross sections are normalized to calculated Monte - Carlo reaction cross section.



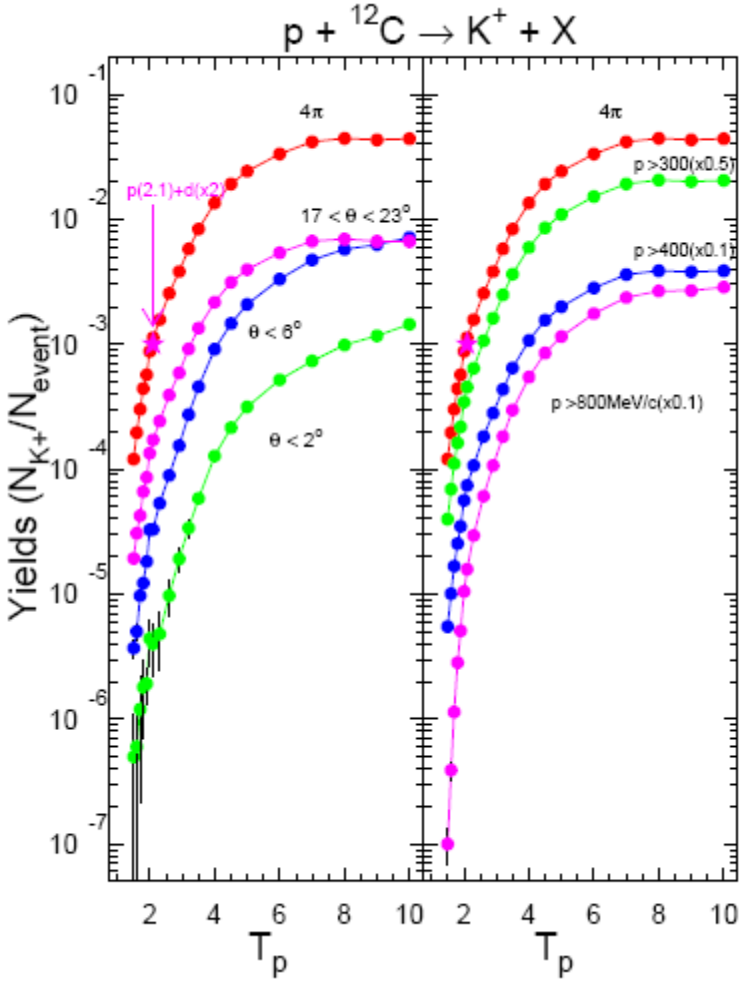


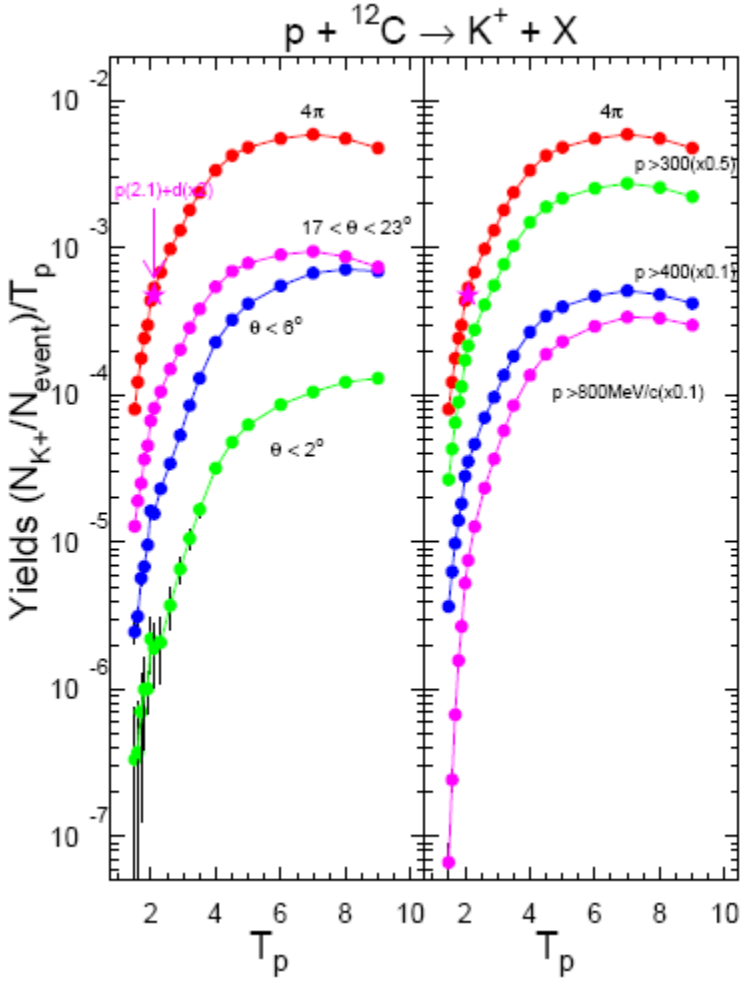
P + C reaction: Inclusive Kaon Production



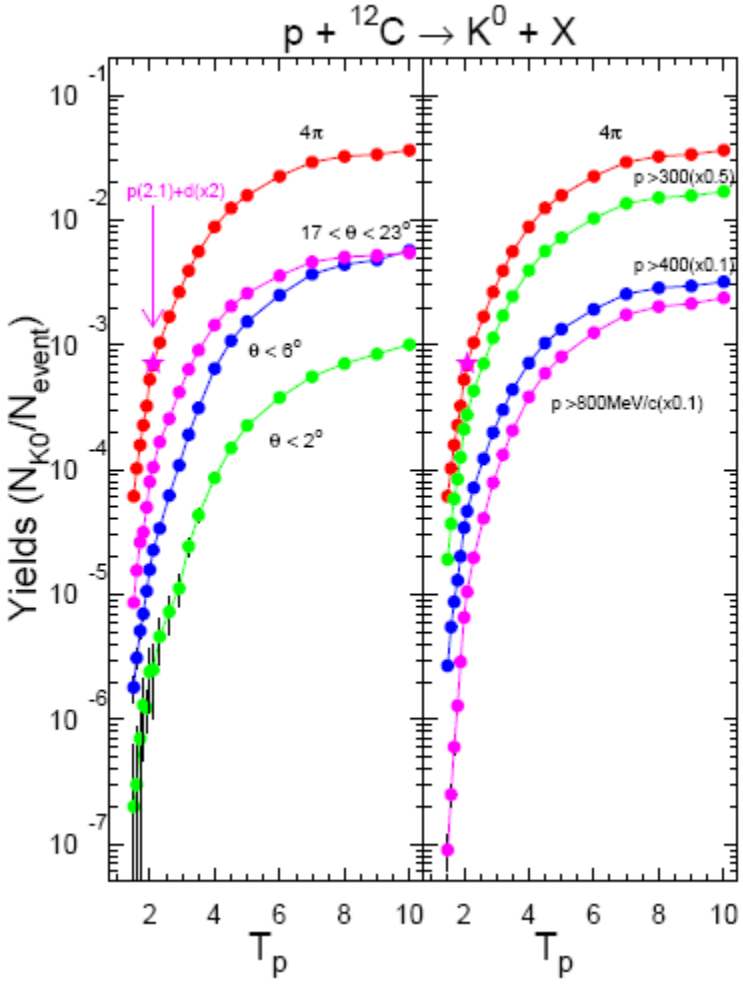


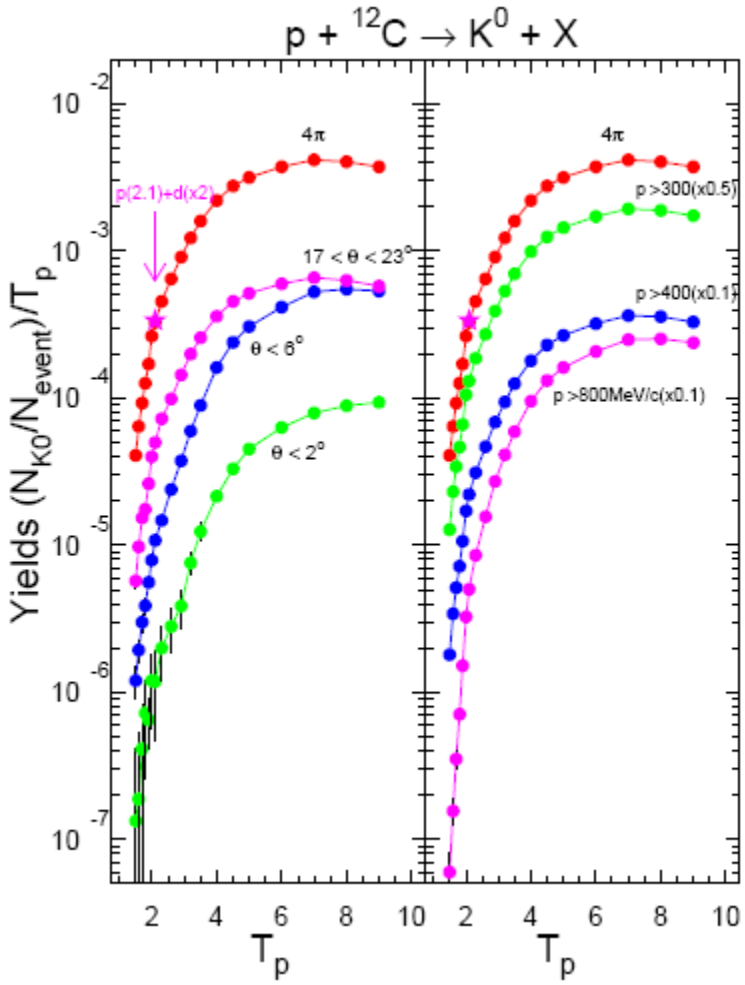
P + C reaction: K^+ production in limited kinematic regions



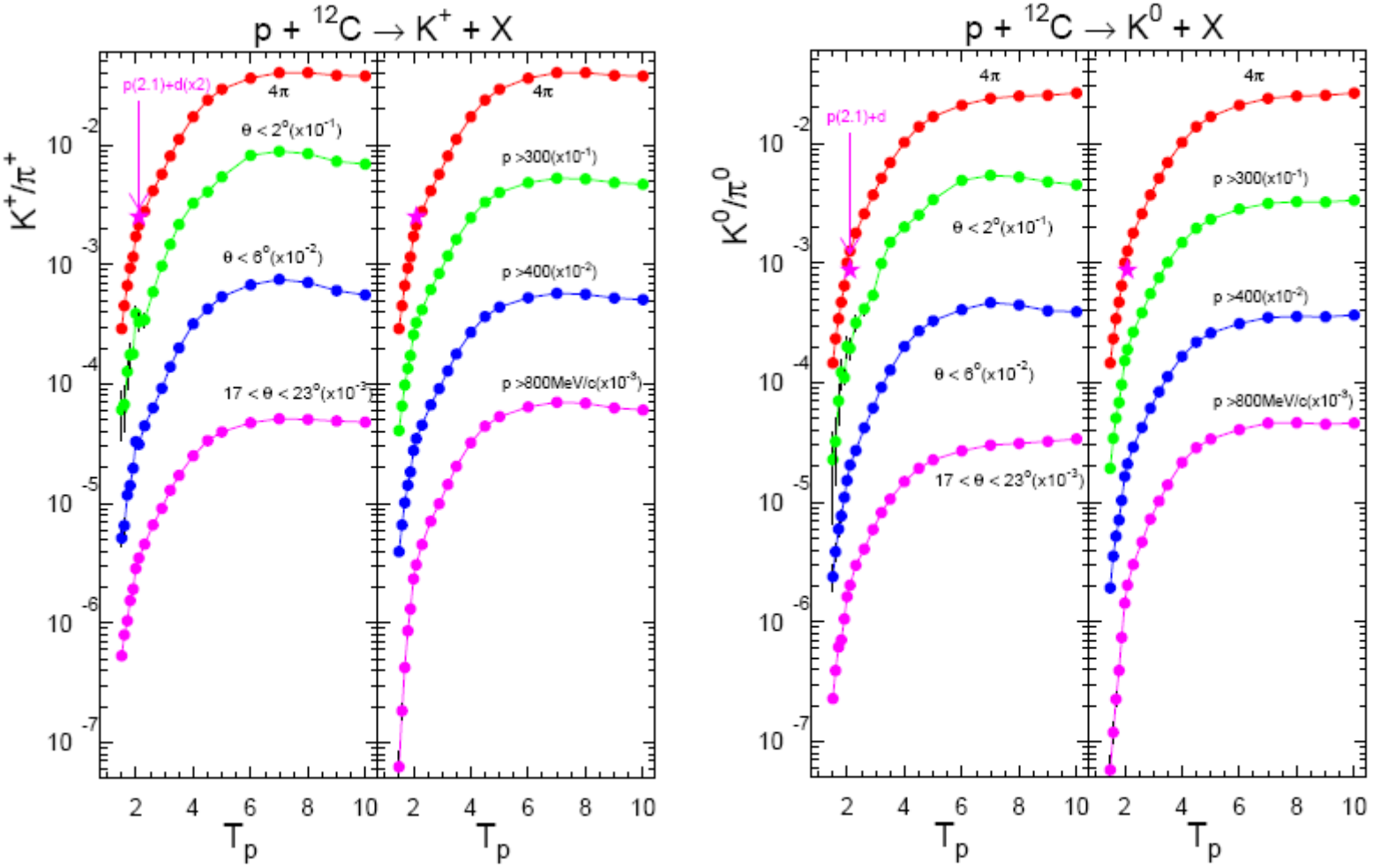


P + C reaction: K^0 production in limited kinematic regions





P + C reaction: K/π ratios in limited kinematic regions



Summary

As a part of the ICD-2 Research Program Task Force activities, substantial efforts have been put on studying feasibility of kaon rare decay experiments as well as Mu2e and Neutrino Factory programs for 2 to 8 GeV proton beams.

LAQGSM09 model has been enhanced and benchmarked at these energies with a focus on consistent particle production description:

- Kaon, hyperon and nucleon production on deuterium and other light nuclei for in a near-threshold region.
- Pion production at $0.1 < p < 0.3$ GeV/c on high-Z nuclei for $3 < T_p < 8$ GeV (Neutrino Factory)
- Pion production at $T < 40$ MeV on high-Z nuclei for $3 < T_p < 8$ GeV (Mu2e)
- First runs with MARS15 (LAQGSM09) have been performed for all of the above for realistic thick targets and capture systems.