Modeling Pion Production at 3 GeV

How to Compare Particle Production at Different Beam Energies

In the staging scenarios, we consider various proton beam energies and beam powers.

We have come to desire particle production rates quoted in a manner that scale simply with beam power.

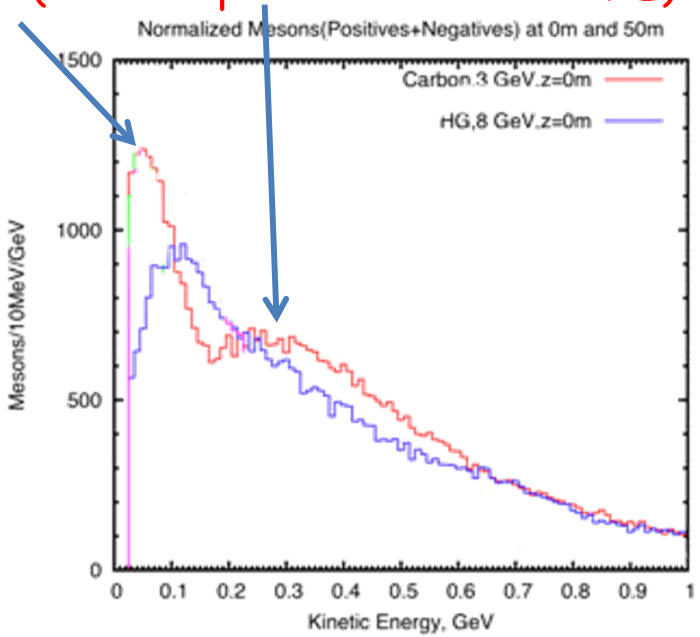
Beam Power = Protons/s $\times$ Beam Energy;

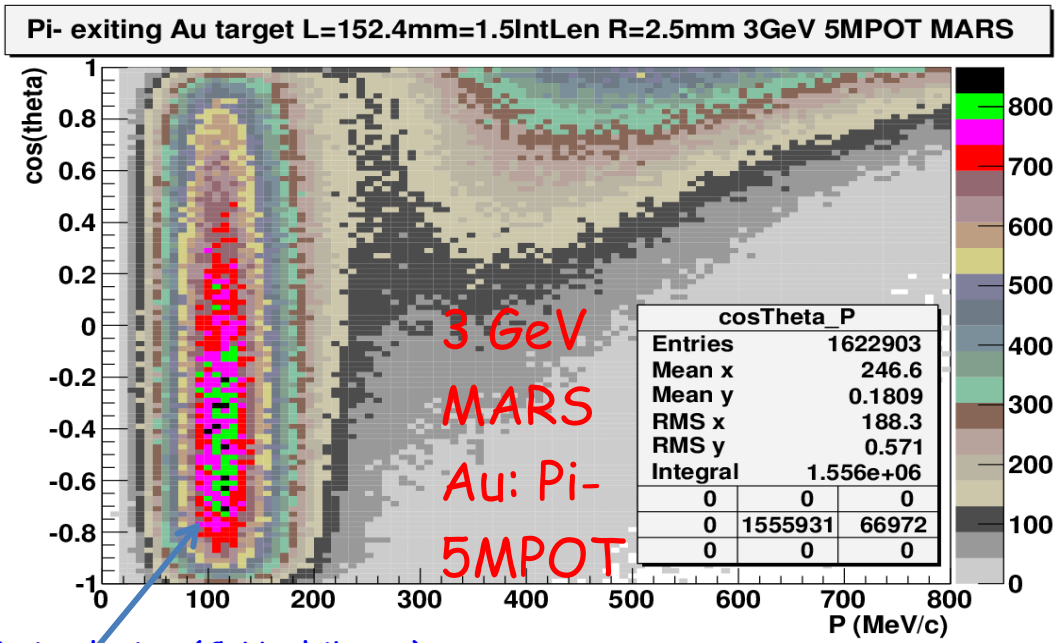
So, if we are interested in, say, "useful" muons per beam power, this is equivalent to ("useful" muons/s) / (proton/s) / beam energy.

In the following we abbreviate this to
Muons / proton / GeV

Soft-Pion-Production Modeling Issues

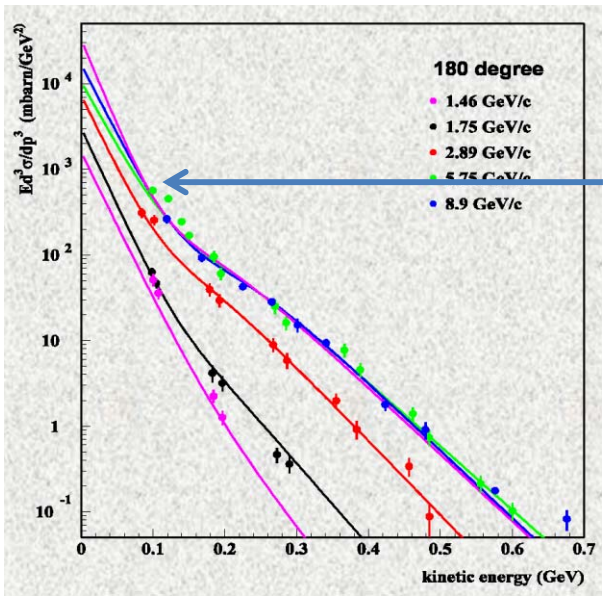
MARS15 simulation (X. Ding) with 3 GeV protons and C target shows large production of soft pions (and 2nd peak at 300 MeV KE). Are these features real?



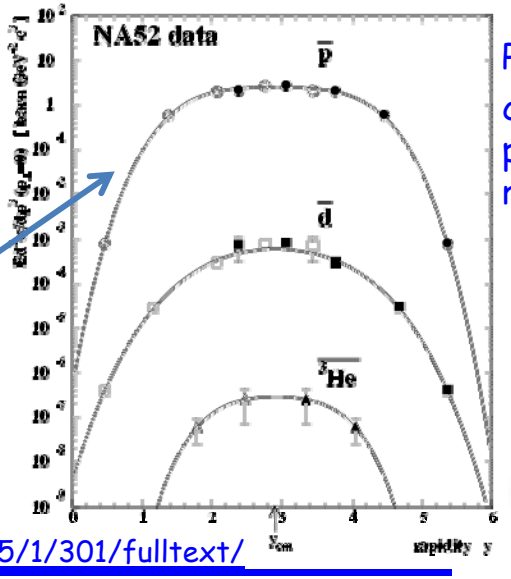


MARS15 simulation (C. Yoshikawa) shows peak of backward π^- with $P \sim 120$ MeV/c independent of angle.

p + Pb Collisions plotted vs. KE



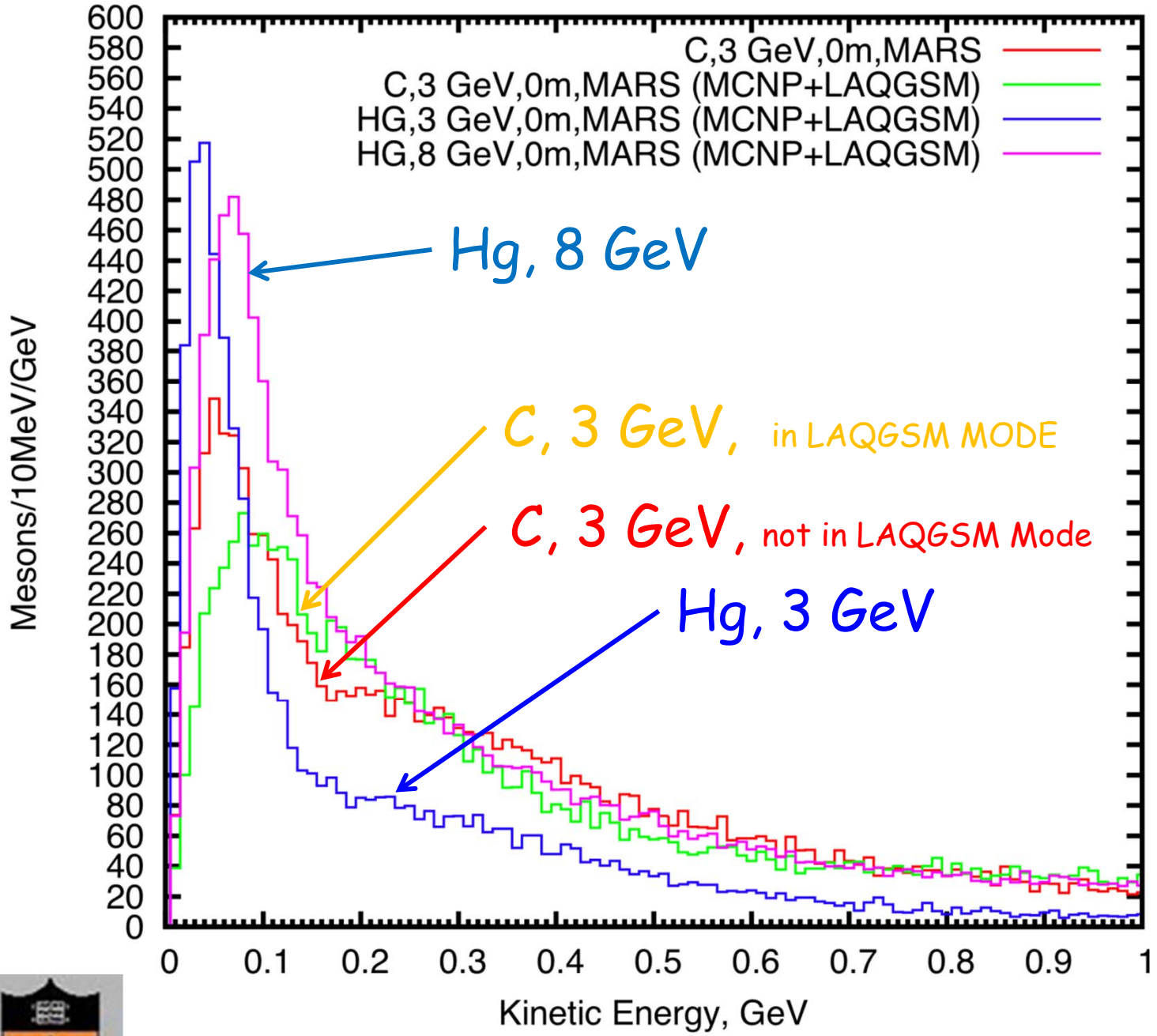
MARS15 model of invariant cross section does not seem to have the required drop-off at low KE (from symmetry of the production cross sections with P_z in the center of mass frame). From Mokhov (1012):
http://accelconf.web.cern.ch/accelconf/HB2012/talks/weo3c05_talk.pdf



Pb + Pb collisions plotted vs. rapidity y

http://iopscience.iop.org/1367-2630/5/1/301/fulltext/

LAQGSM Mode ⇔ Better MARS Model below 5 GeV



Pion production @ 3 GeV via MARS in LAQGSM mode seems much more plausible than when not in this mode.

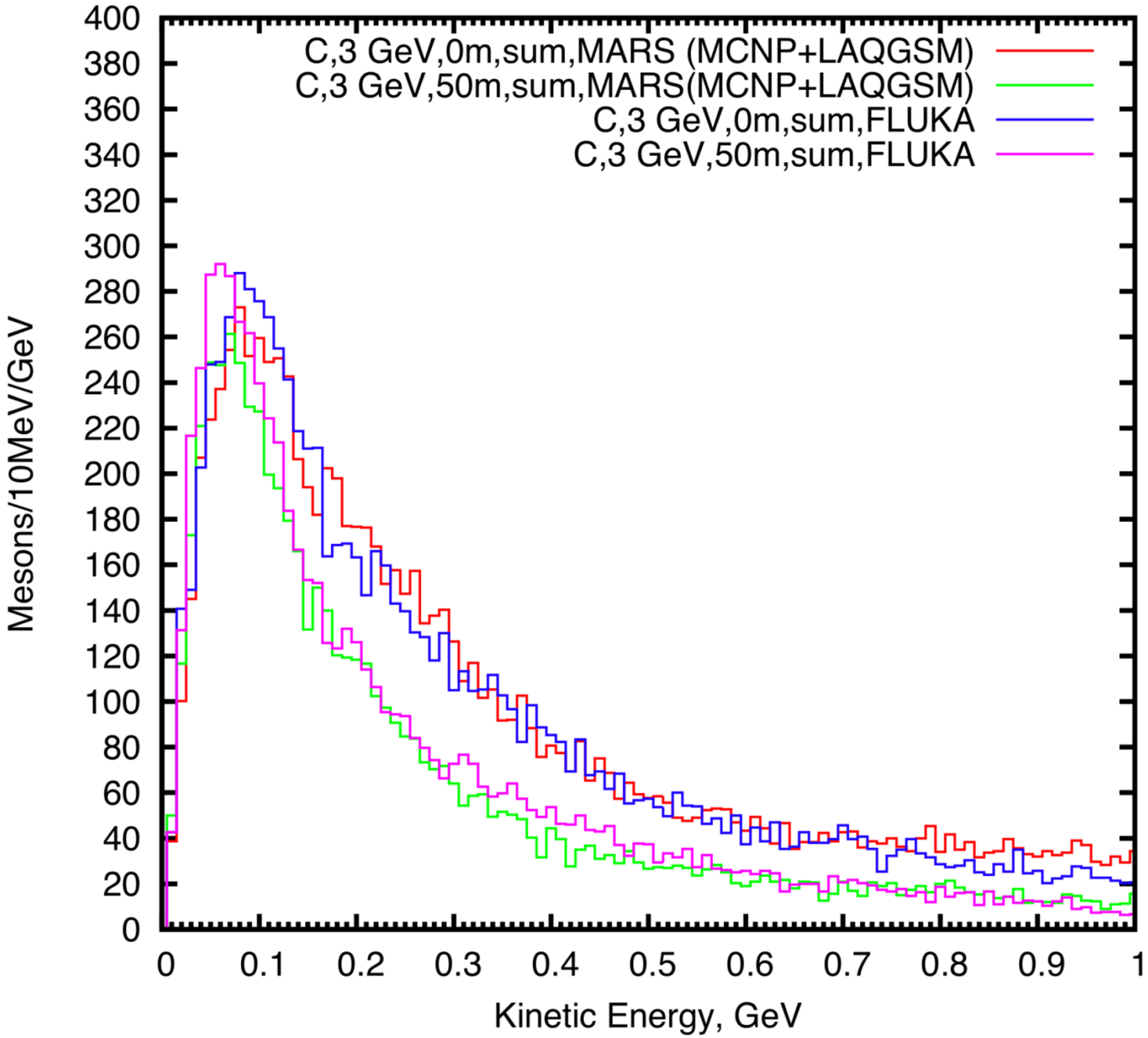
As reported previously, pion production off Hg target is lower at 3 GeV than at 8 GeV by almost a factor of 2.

Pion production off C target at 3 GeV is about $\frac{3}{4}$ that off Hg target at 8 GeV, but greater than that off Hg at 3 GeV.

Pion production off C target at 3 GeV and 1 MW is about 1/5 that off Hg at 8 GeV and 4 MW.

X. Ding: http://puhep1.princeton.edu/~kirkmcd/mumu/target/Ding/ding_130905.pdf

MARS in LAQGSM Mode Agrees Well with FLUKA @ 3 GeV



Summary

Models of particle production below 5 GeV are delicate, but MARS in LAQGSM Mode seems robust enough for us to proceed.

At 3 GeV, a carbon target is favored over a mercury one in terms of rate alone (and a carbon target is very viable in a 1 MW beam).

Pion/muon production at 3 GeV, 1 MW with a carbon target will be about 1/5 that with a mercury target at 8 GeV and 4 MW.

Delivering a short pulse in a single proton beam will be difficult at 3 GeV, so we may need to consider multiple beams (onto a single target).

Optimization for the configuration of carbon target, capture solenoid magnets, and possible multiple proton beams should begin now.