Production of charged pions in reaction p+Nb at 3.5 GeV

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- main motivation – normalization of dilepton results

  (cross sections)

  specific case: usual method for pp and AA cannot be used

  no time-of-flight measurement

# Normalization of HADES dilepton spectra

A+A reactions - charged pion multiplicities (N_π per reaction) extraplated to full solid
             angle

p+p   - elastic scattering

p+A   - extrapolation to 4π not possible, highly asymmetric system,
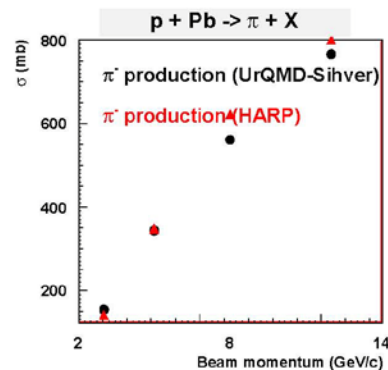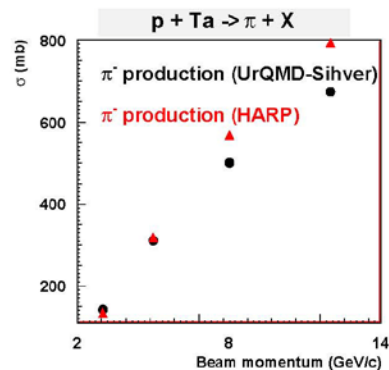   target rapidity not covered

             - normalization to measured charged pion cross sections from other
               experiments

Measured π cross sections from pA
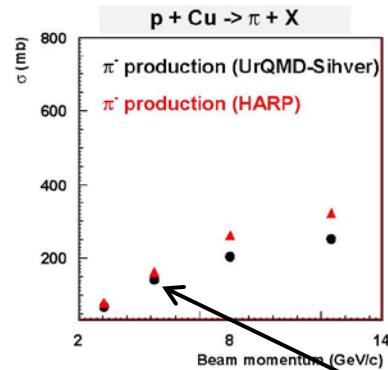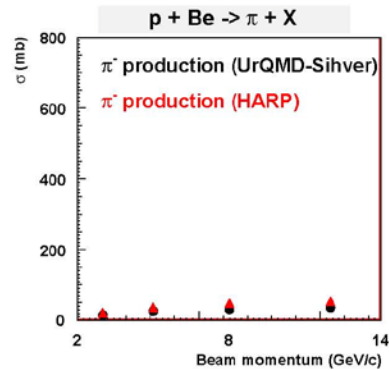
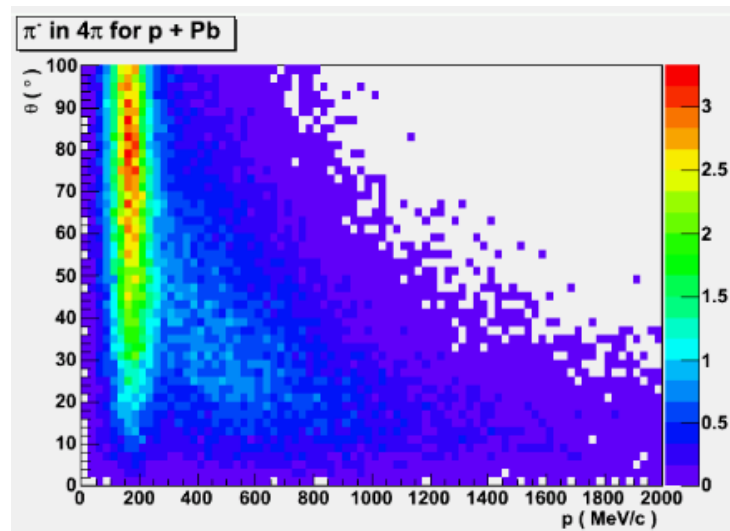200 < mom < 1000 MeV/c
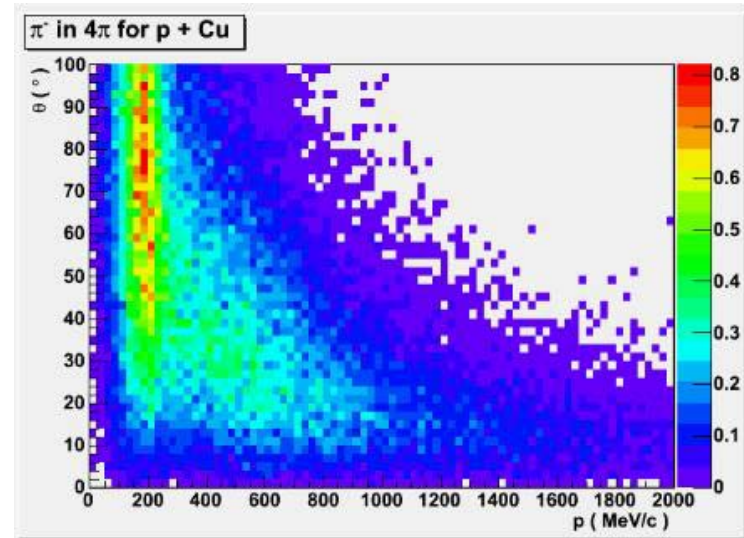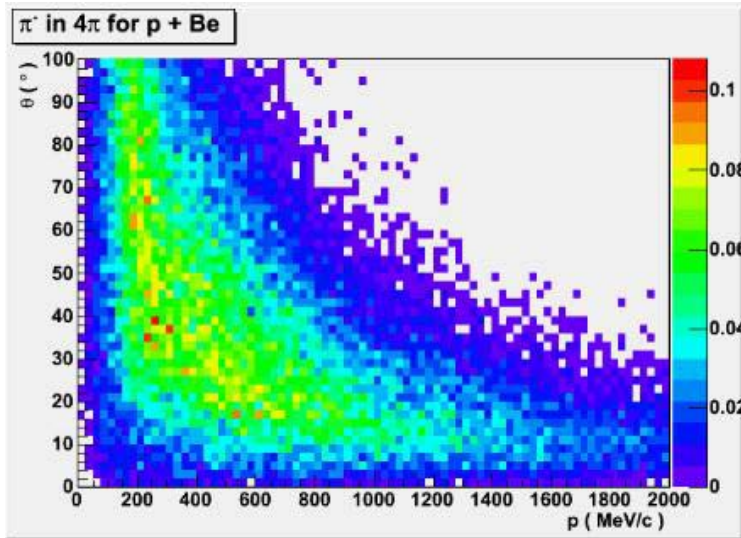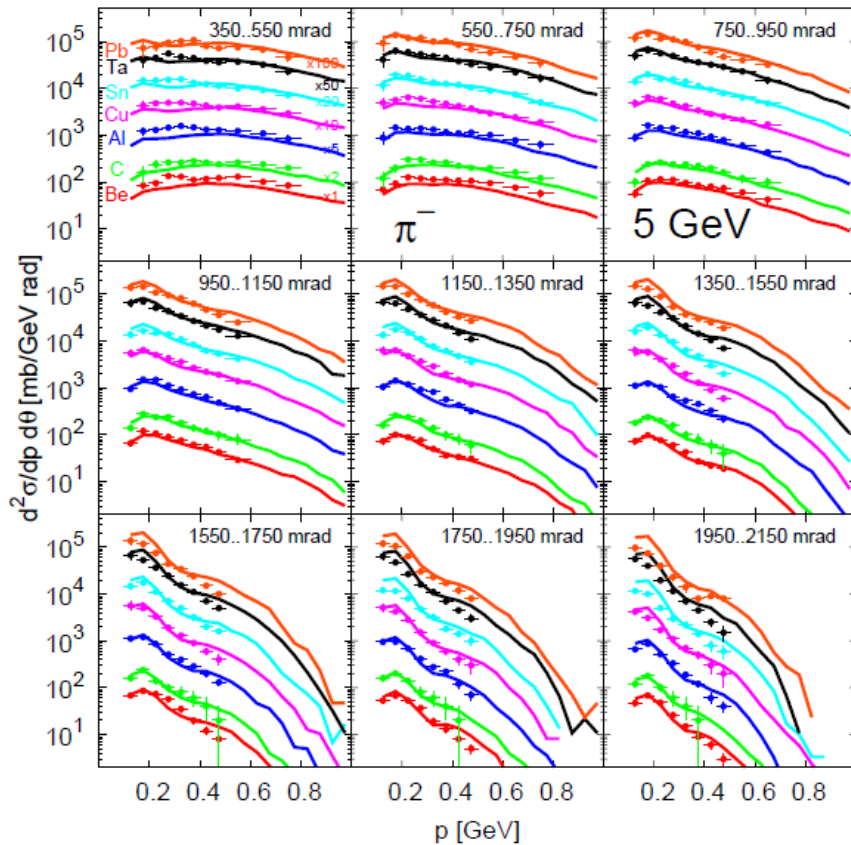
30° < θ < 90°

closest system to

p+Nb at 3.5 GeV

Bolshakova A. et al. **HARP-CDP collaboration**

EPJ C63 (2009) 549-609., EPJ C64 (2009) 181-241.

π cross sections from pA – UrQMD

π⁻ in 4π for p + Be

π⁻ in 4π for p + Cu

π⁻ in 4π for p + Pb

π cross sections from pA – comparison to GiBUU

K.Gallmeister, U.Mosel, arXiv:0901.1770 [hep-ex]
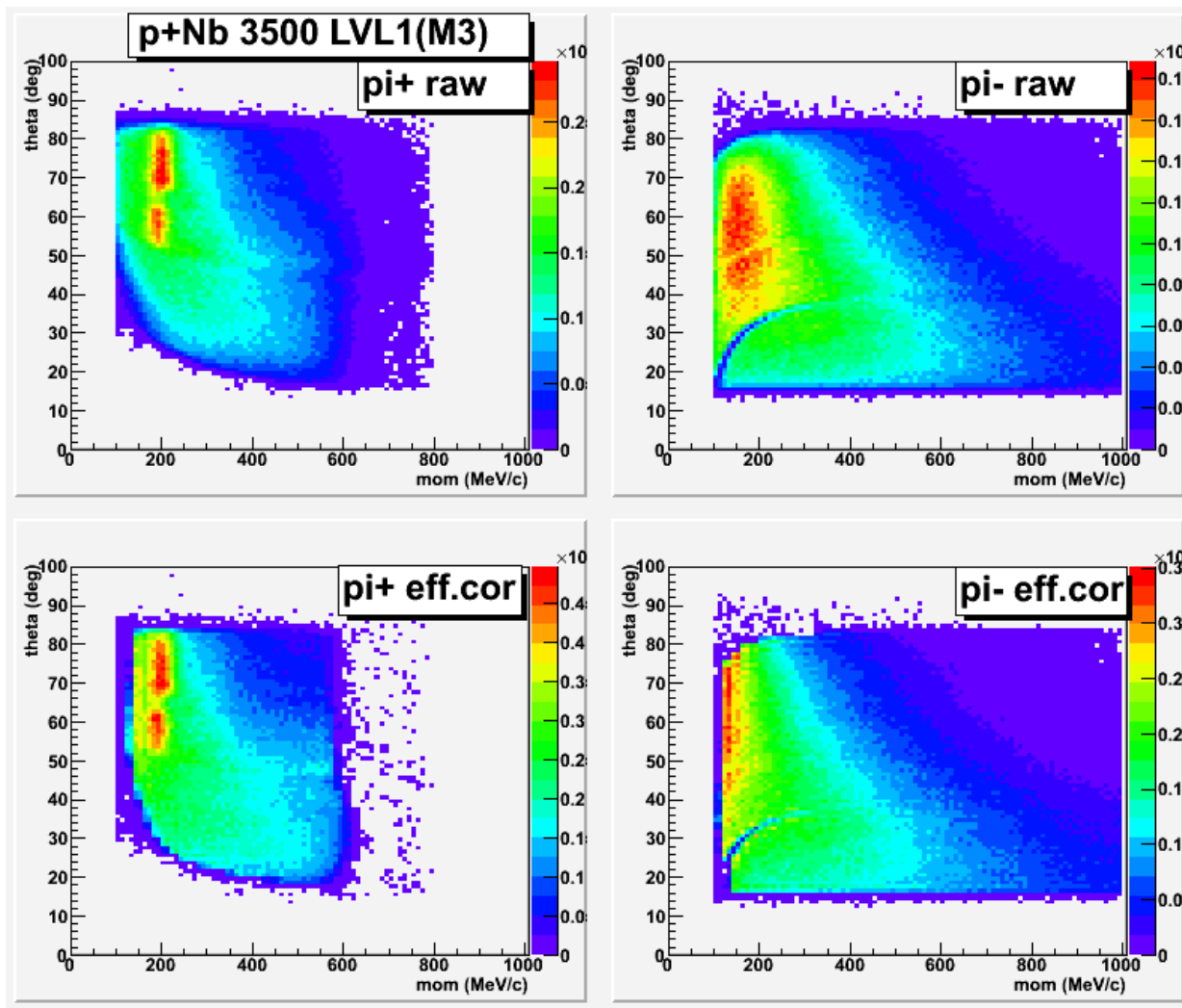
http://gibuu.physik.uni-giessen.de/GiBUU/wiki/HarpGallery

Analysis - Event selection and PID

• LVL1 events with $M_{charged.}$>=3, 10 M events analyzed

• LVL1 events with $M_{charged}$>=2, 10 M events analyzed

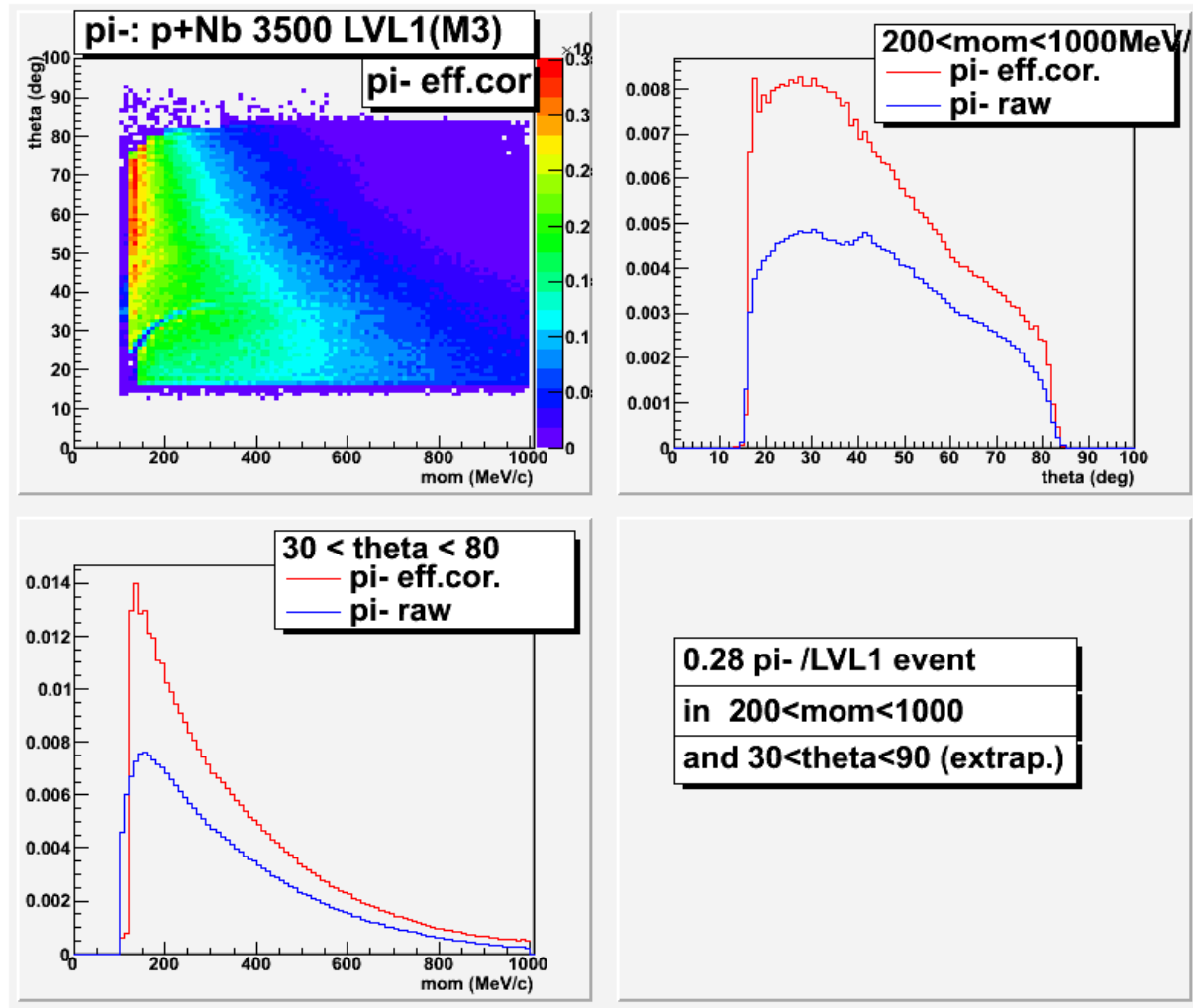• UrQMD events, LVL1 emulation, 1 M events analyzed

• PID – energy loss in TOF/TOFINO and momentum
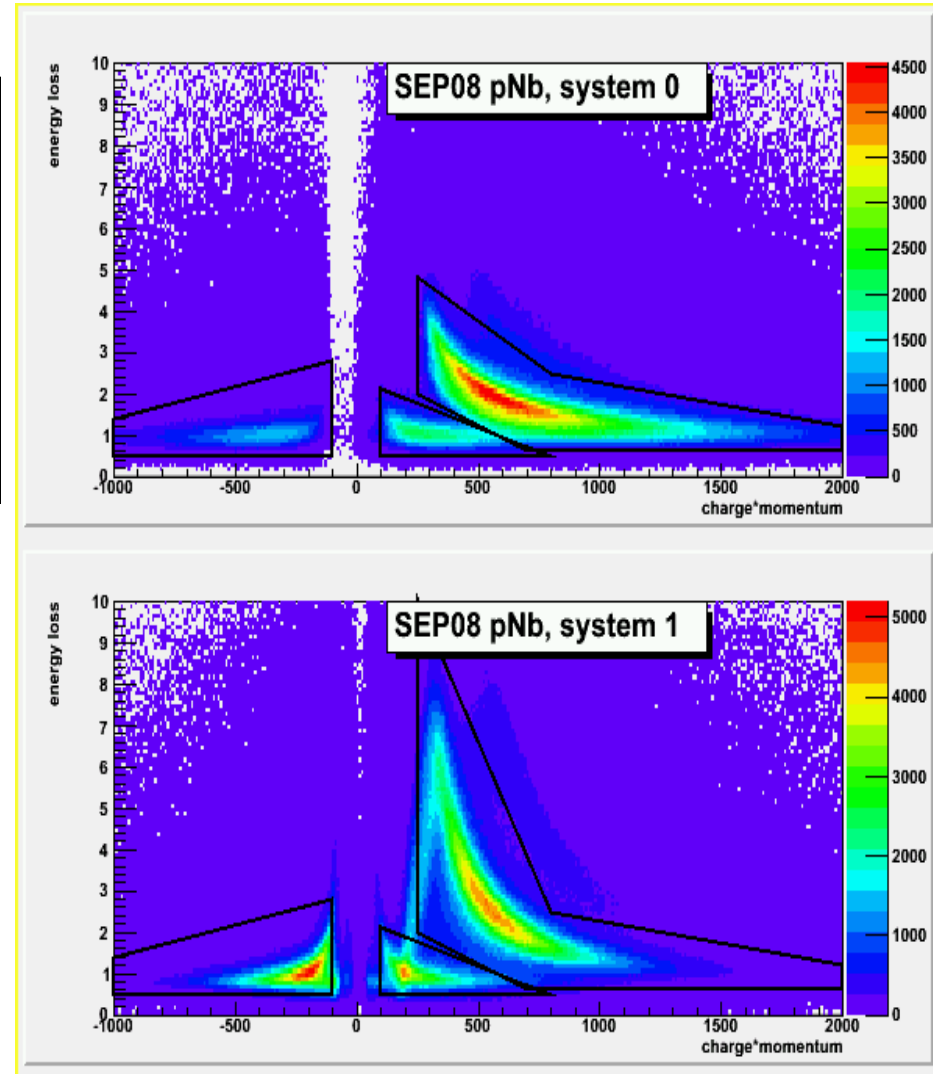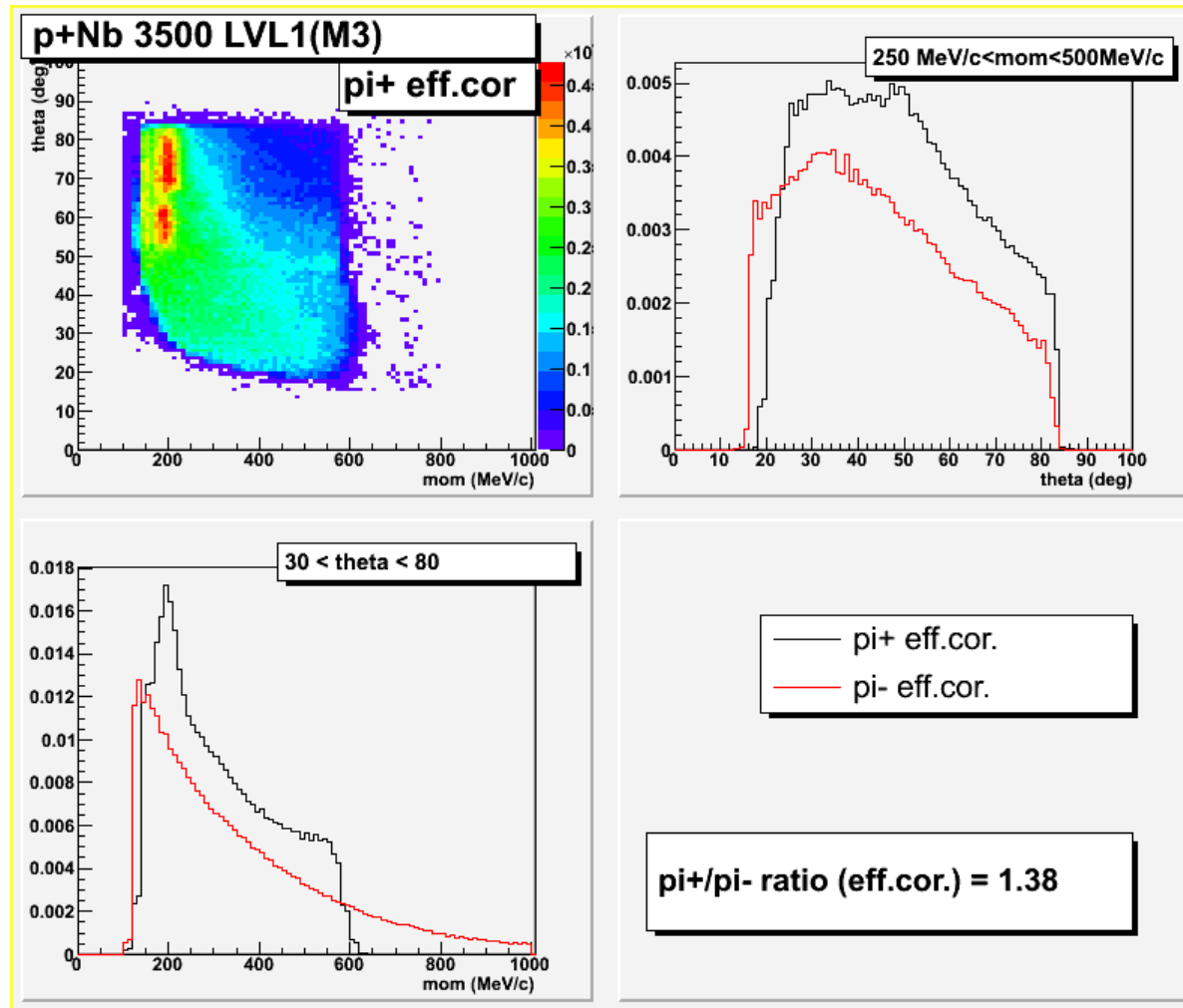
Theta vs momentum distributions

pion multiplicities – π⁻

0.28 π^-/LVL1 event in region where HARP shows π^- cross section

only 7% extrapolation of our data from $30° < \theta < 80°$ to $30° < \theta < 90°$

Pion multiplicities - π^+/π^- ratio

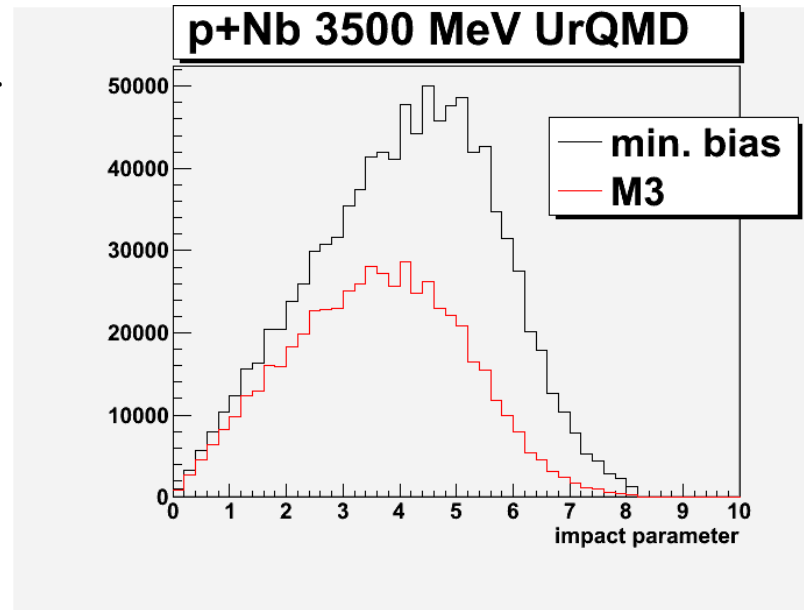good ID for π^+ only for 250<mom<500

π^+/π^- ratio is 1.4 ± 0.1   HARP-CDP pCu 4.15GeV π^+/π^- ratio = 1.3

UrQMD pion multiplicities to 4π

centrality selection

by the M3 LVL1 trigger

(UrQMD):

	<b> (fm)	$<M_{\pi+}>$	$<M_{\pi-}>$	$<M_{\pi0.}>$
min. bias	4.10	0.648	0.568	0.661
LVL1	3.60	0.775	0.761	0.759

π^- multiplicities in HADES acceptance - dependence on trigger
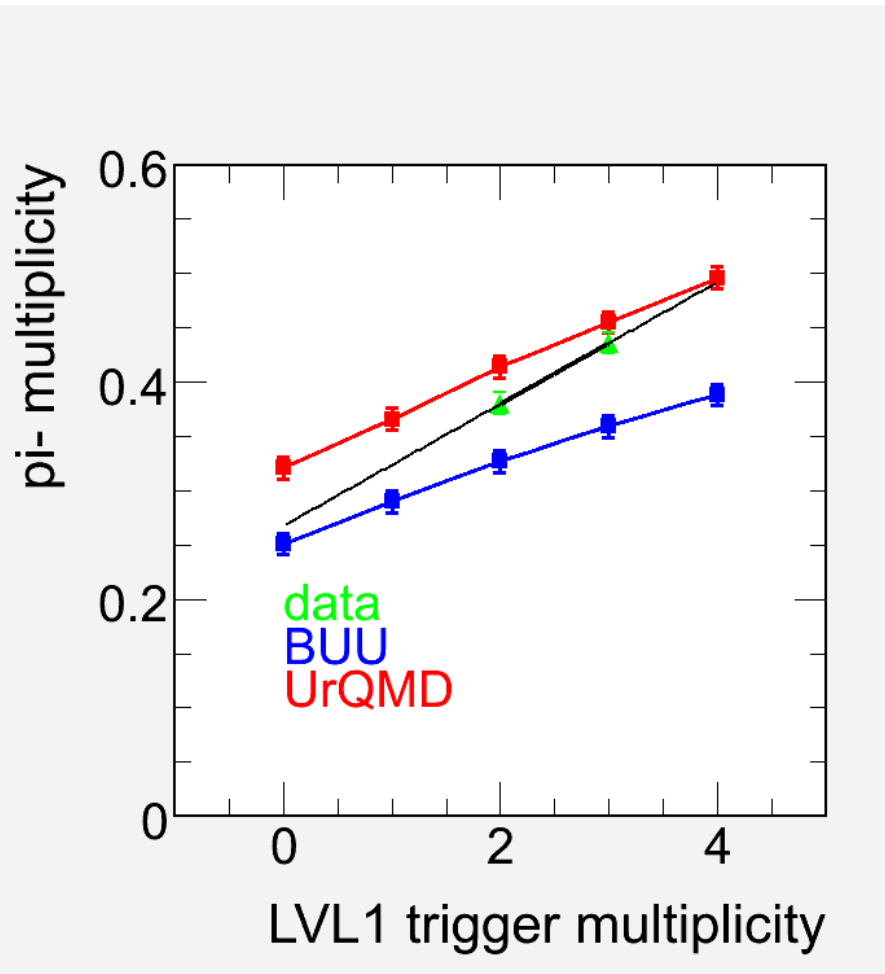
UrQMD: ratio M3/min.bias in HADES acceptance region = 1.42

BUU: ratio M3/min.bias in HADES acceptance region = 1.42

systematic error ~10%

Comparison to HARP-CDP data

HARP   - cross section for pi- in 30<theta<90 and 200 < mom < 1000 MeV/c

      for p+Cu at 5 GeV/c (= 4.15 Gev kin. energy) is   162 mb

      for p+Ta at 5 GeV/c (= 4.15 Gev kin. energy) is   317 mb

        p+Nb at   3.5   GeV   156 mb (interpolation)

HADES - 0.28 pi- per LVL1 event p+Nb at 3.5 GeV

    - assuming trigger bias ratio from UrQMD = 1.42

      0.28/1.42 = 0.20 pi- per p+Nb reaction

    - assuming p+Nb reaction cross section 982 mb

      R. K. Tripathi, F. A. Cucinotta, J. W. Wilson, Nucl. Instrum. Meth. B117 (1996) 347

      pi- cross section 0.20 * 982 mb = 196 mb   22% difference
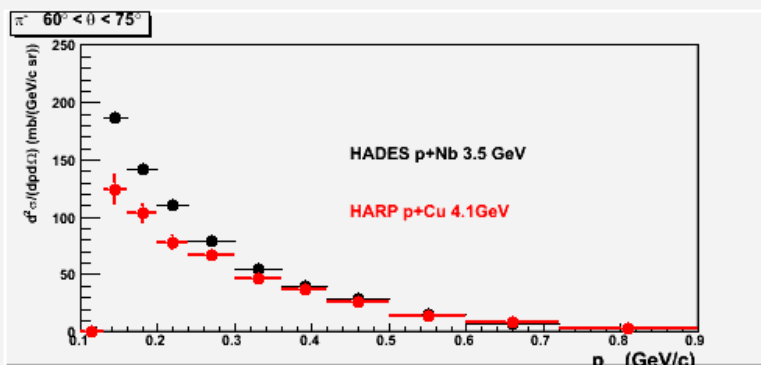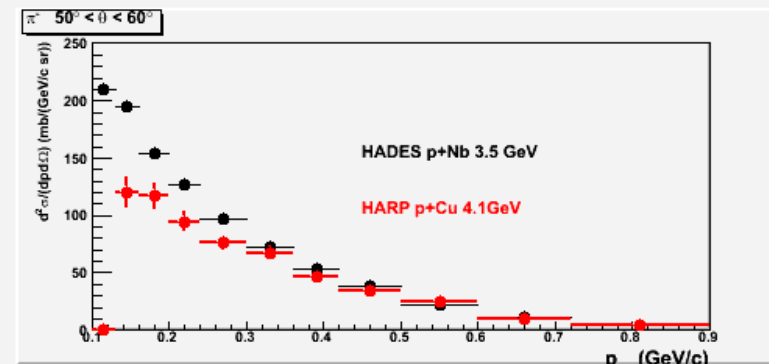

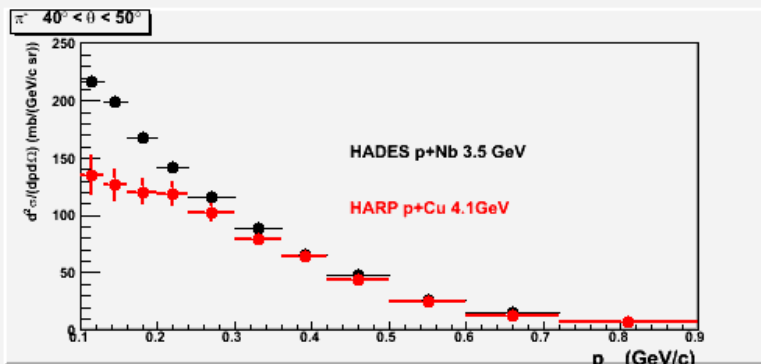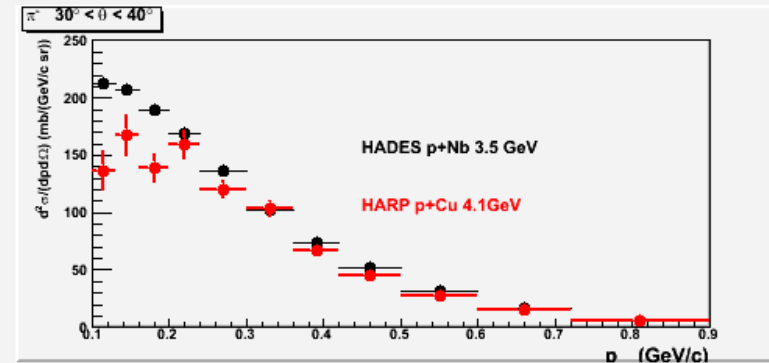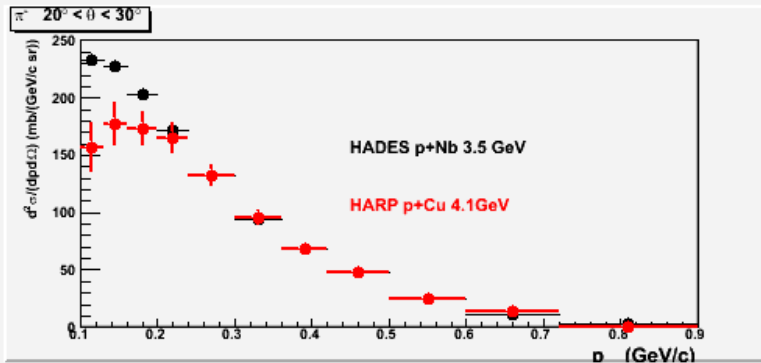errors   - statistical negligible

    - systematic - efficiency   <5% from sector differences (see phi distribution)

              - method   <5% from selfcheck

              - normalization to 1 LVL1 event <5% from track mult. distribution

              - correction on LVL1 bias ~ 10% from UrQMD and M3-M2

Comparison to HARP-CDP data – pCu 4.1GeV

HADES data:

$$\sigma_\pi = M_\pi * \sigma_{tot}$$

σ_{tot} - reaction cross section 982 mb

HARP data:

scaled by factor 0.96

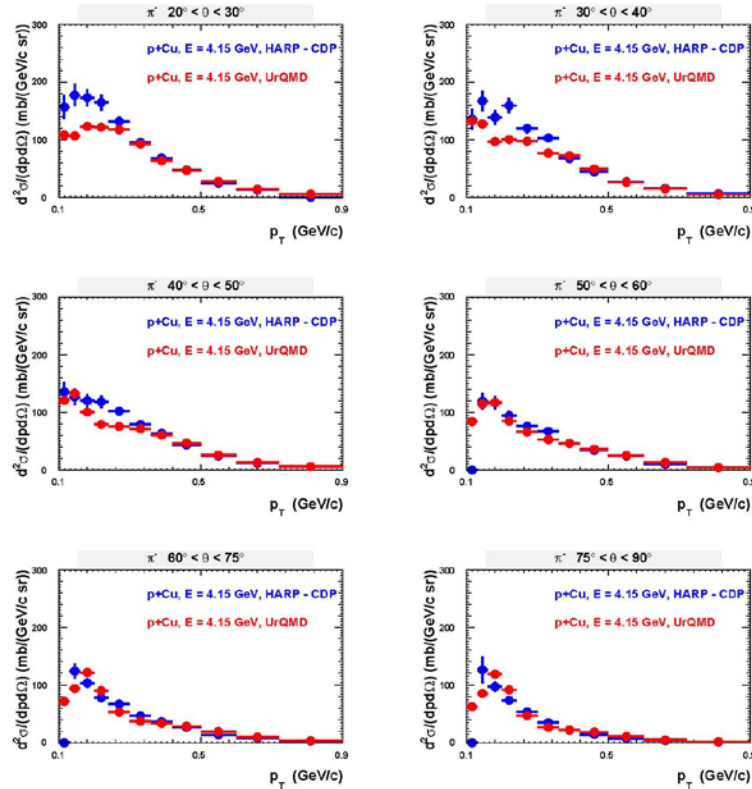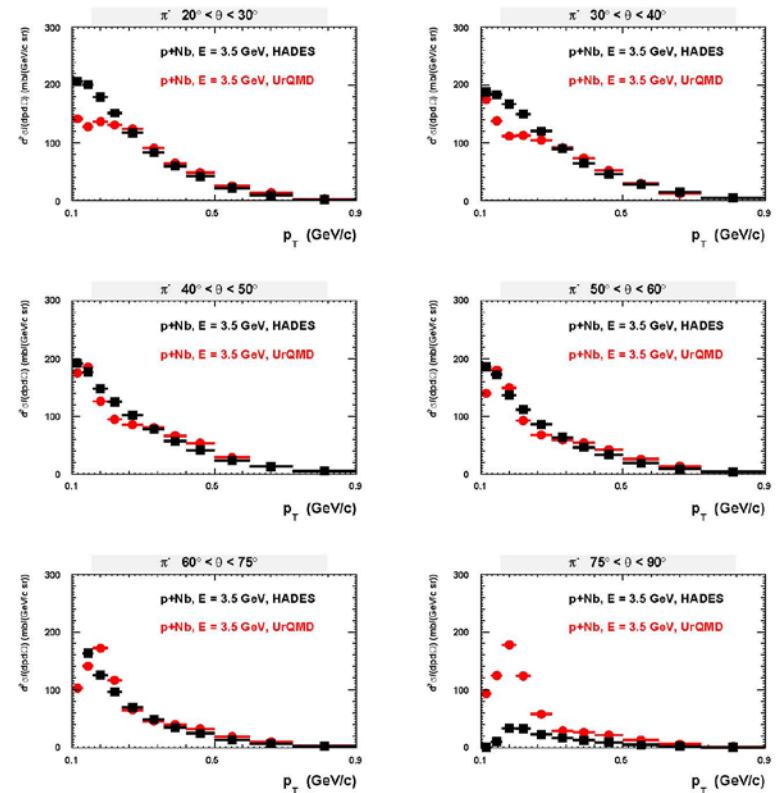# Comparison to UrQMD
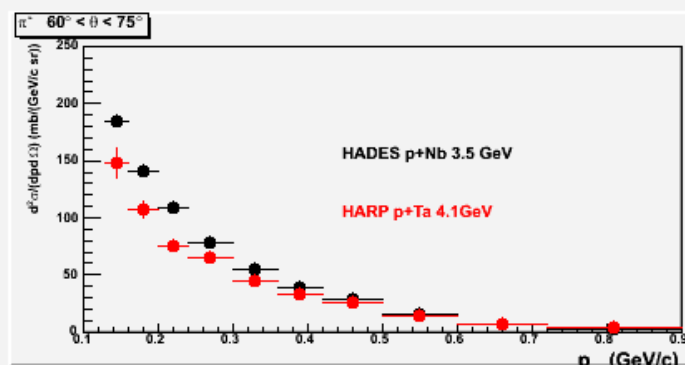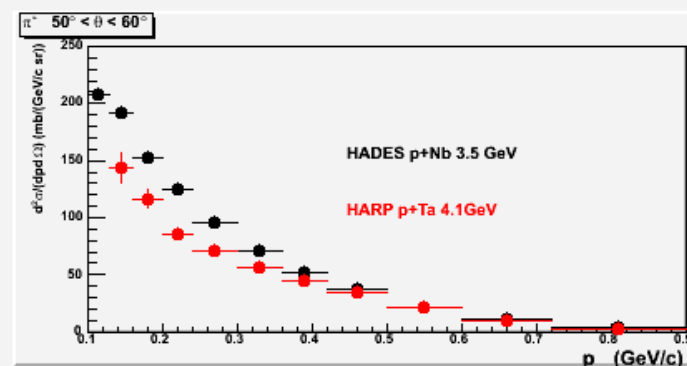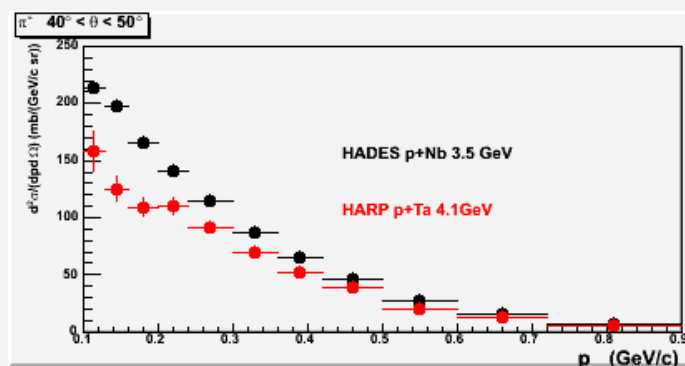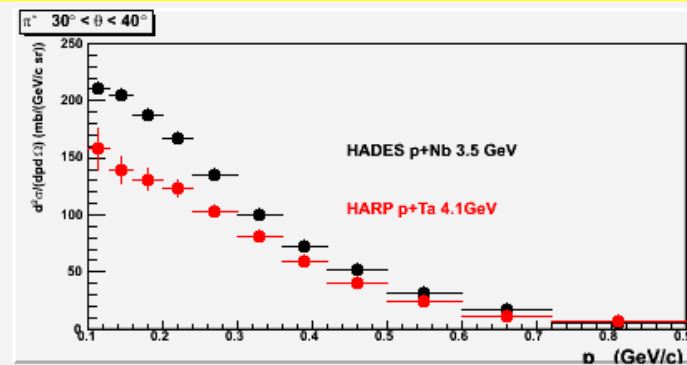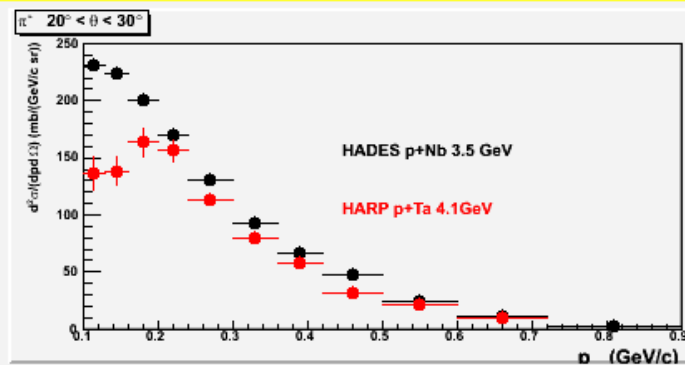
pCu 4.1GeV

pNb 3.5GeV

Figure 2:

Figure 3:

UrQMD predicts different shapes for different systems
Qualitatively in agreement with data

4

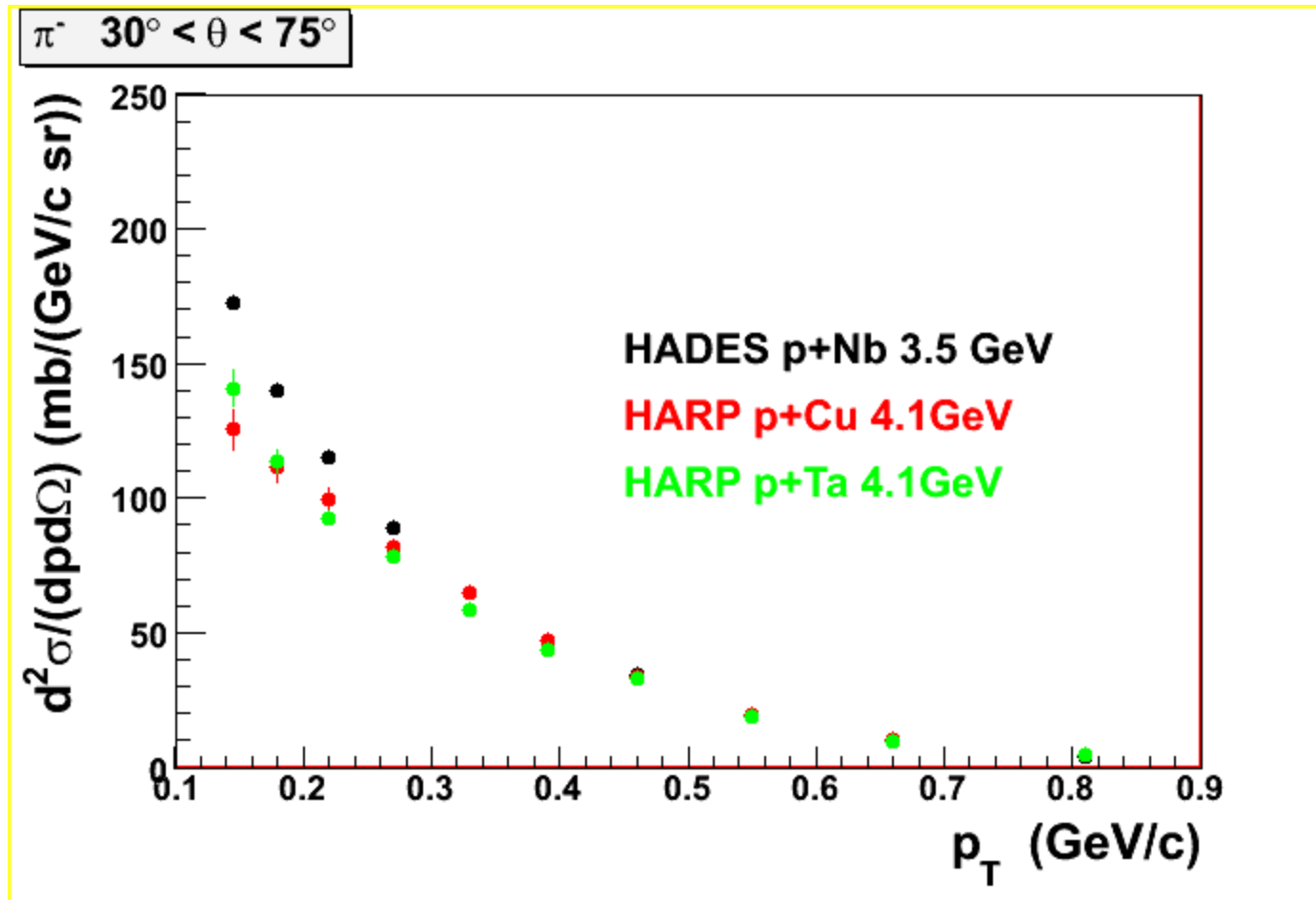# Comparison to HARP-CDP data — pTa 4.1GeV

HADES data:

$$\sigma_\pi = M_\pi * \sigma_{tot}$$

σ_{tot} - reaction cross section 982 mb

HARP data:

scaled by factor 0.48

Normalization to HARP-CDP data

π^- $30° < \theta < 75°$

HADES p+Nb 3.5 GeV

HARP p+Cu 4.1GeV

HARP p+Ta 4.1GeV

HADES data: $\sigma_\pi = M_\pi * \sigma_{tot}$

σ_{tot} - reaction cross section from scaling of HADES data to HARP pCu data for mom>300 MeV/c
where the shapes are the same

Result : 886 mb - difference from the model prediction is 12%

Summary

charged pion production from p+Nb at 3.5 GeV was studied

π^- multiplicities were scaled to measured cross sections (HARP-CDP)
scaling constant - the total reaction cross section $\sigma_{tot} = 886 \text{ mb}$ can be used for recalculation
of dilepton multiplicities to cross sections

errors from analysis - statistical negligible
                      - systematic 10-15%

error from scaling   - fitting error 2.3%

error of HADES-HARP comparison (differences in p_T shapes, different systems…):
   (886.-791.)/886. == 0.11 == 11%   difference between full p_T range and p_T>300MeV/c
   (886.-982.)/886. == 0.12 == 12%   difference between our result and parametrization model

References

A. Bolshakova et al. **HARP-CDP collaboration** EPJ C63 (2009) 549-609.

A. Bolshakova et al. **HARP-CDP collaboration** EPJ C64 (2009) 181-241.

R. K. Tripathi, F. A. Cucinotta, J. W. Wilson, Nucl. Instrum. Meth. B117 (1996) 347

K.Gallmeister, U.Mosel, arXiv:0901.1770 [hep-ex]

http://gibuu.physik.uni-giessen.de/GiBUU/wiki/HarpGallery
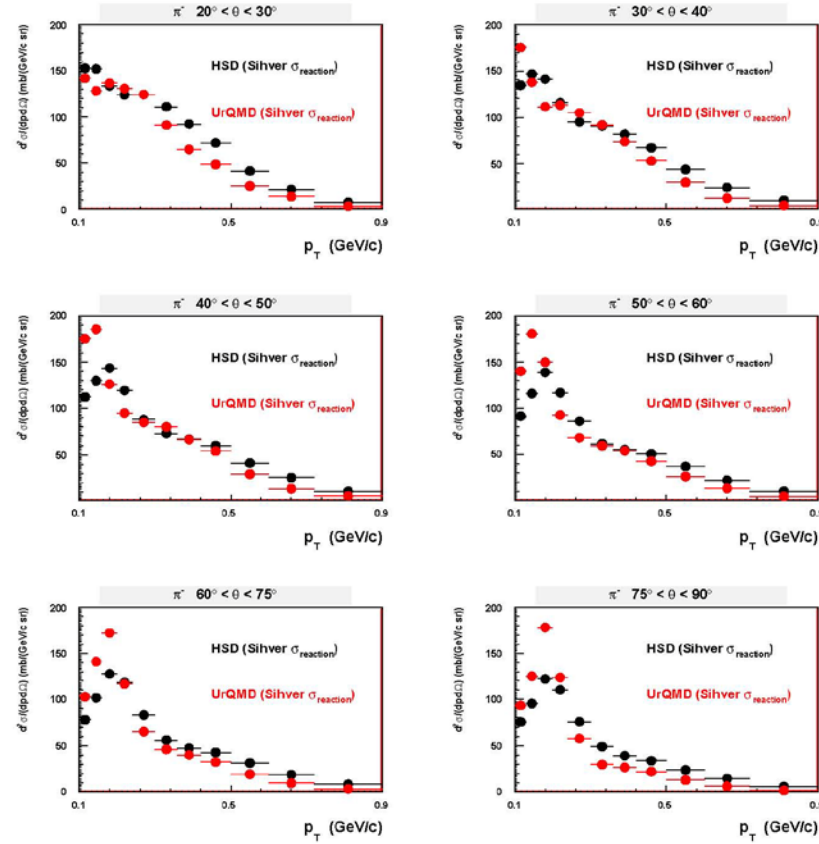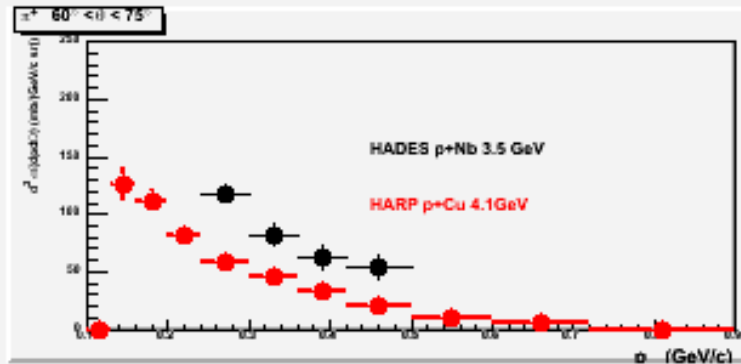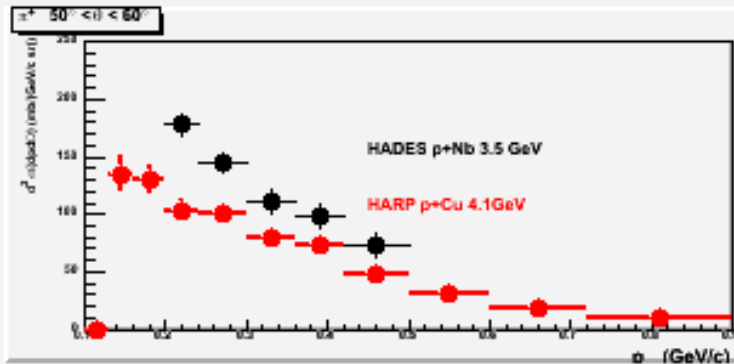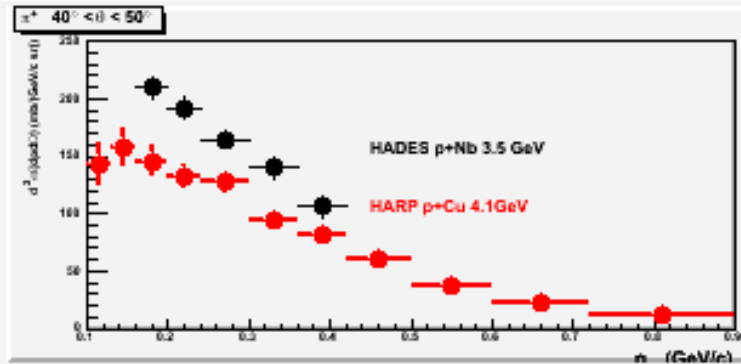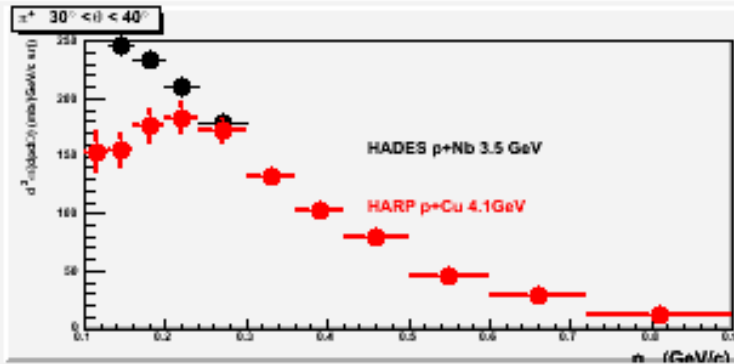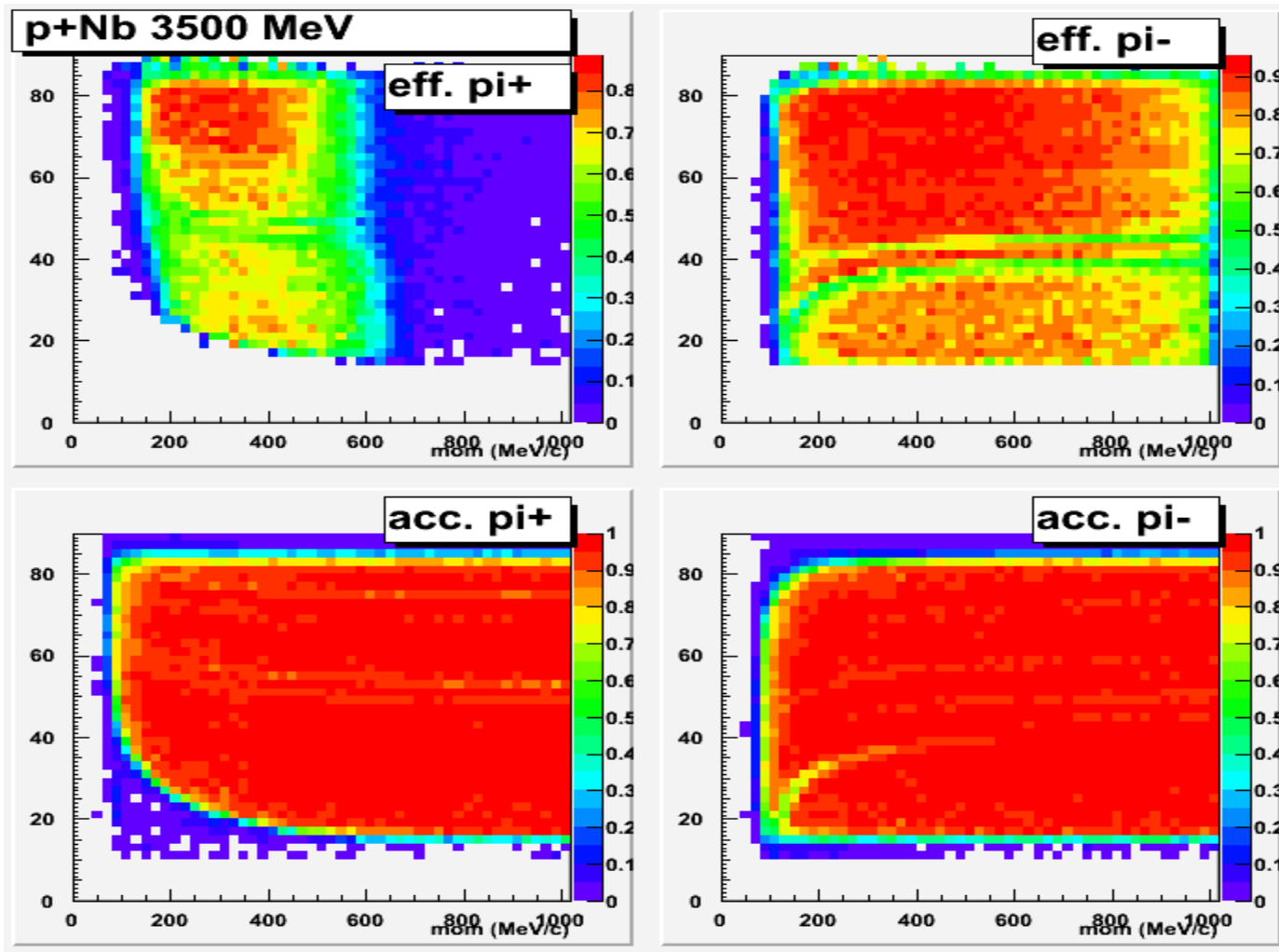
Comparison of UrQMD and HSD for pi-

Figure 8: $d\sigma/d\Omega dp$ for different polar angles for π^- production in p+Nb at $E_{kin} = 3.5 GeV/c^2$.

Comparison to HARP data for pi+
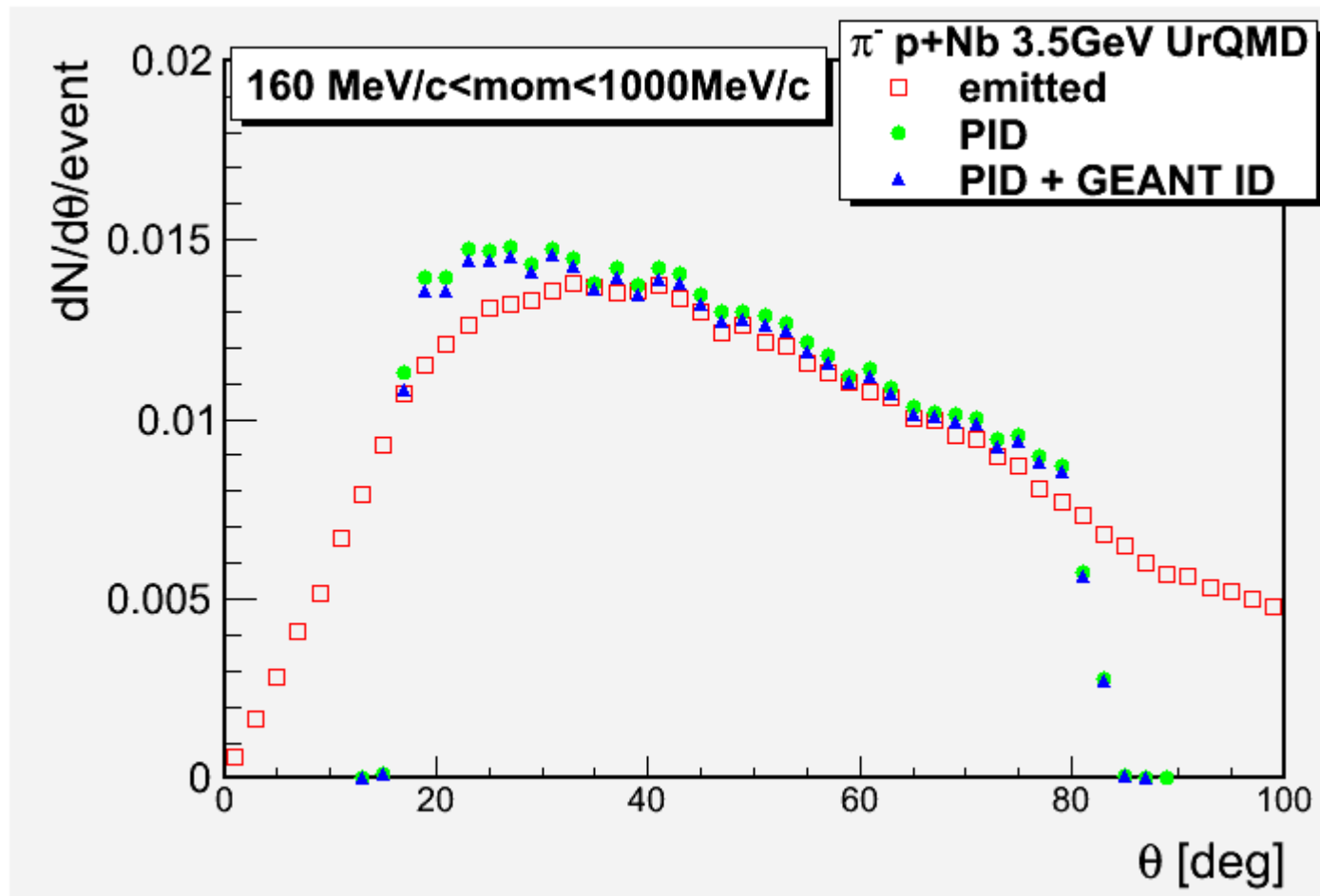
Analysis - Acceptance and efficiency
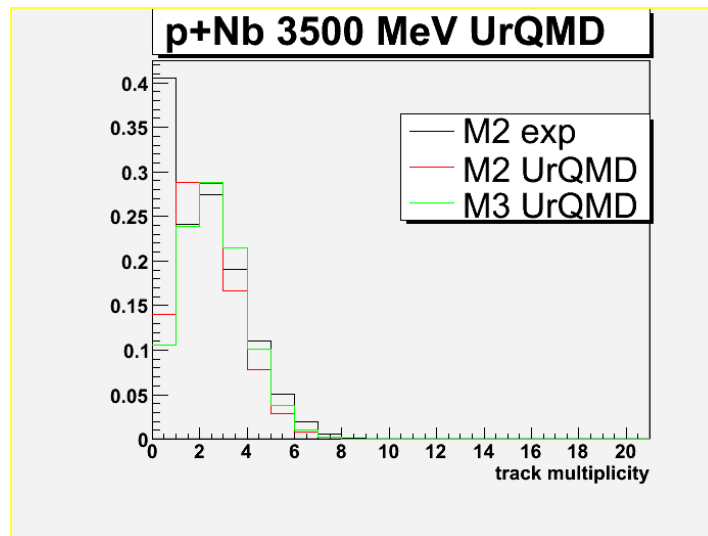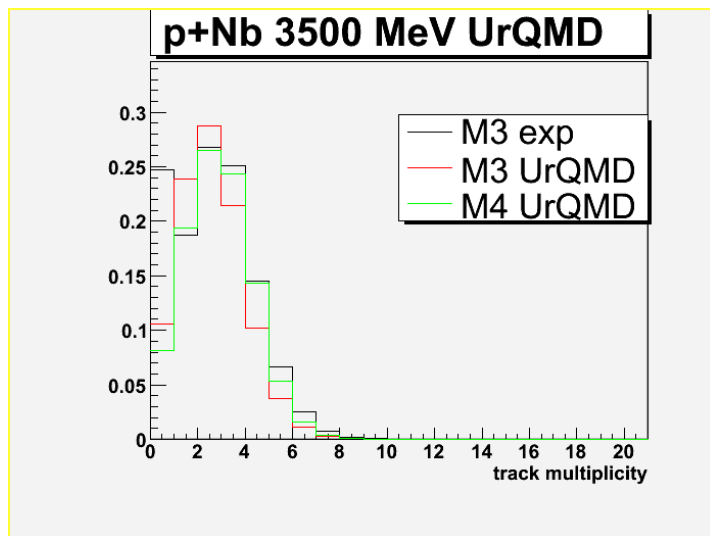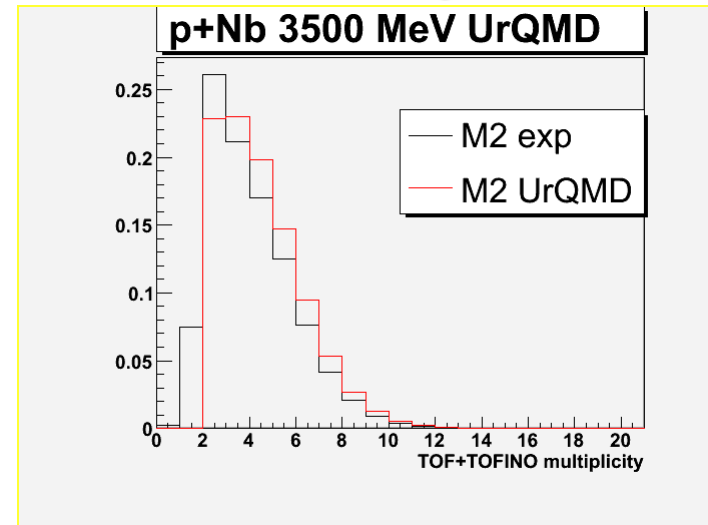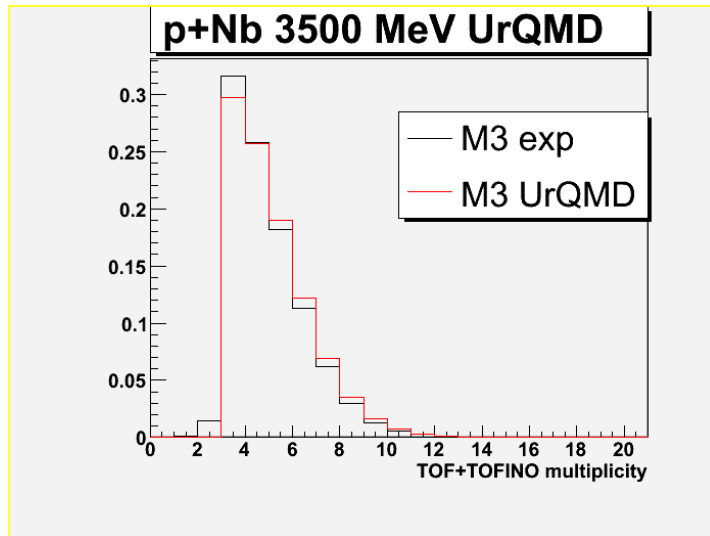

theta vs mom

for phi=90 deg.

calculated using PLUTO white distribution embedded
into real data, includes tracking and PID
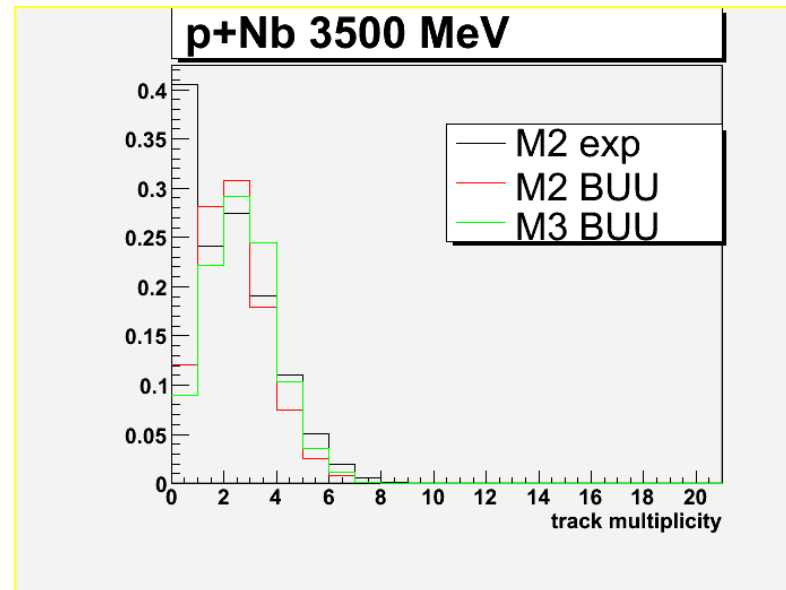
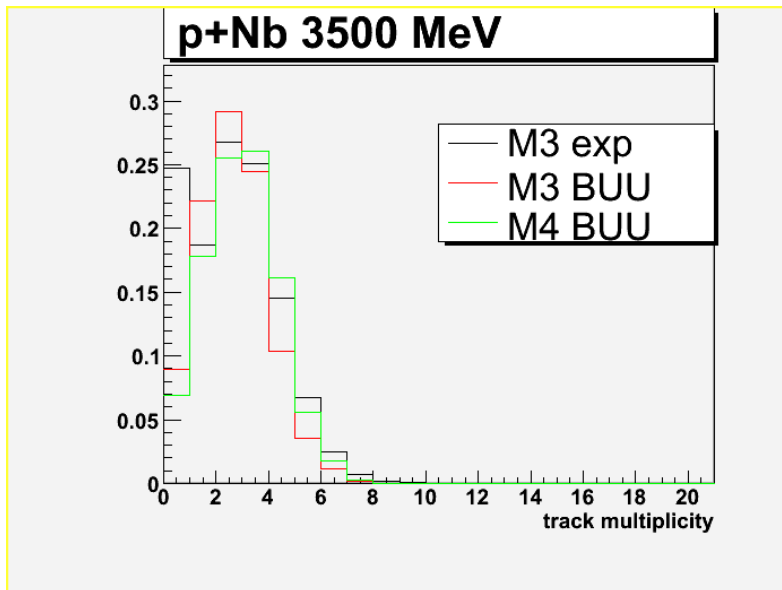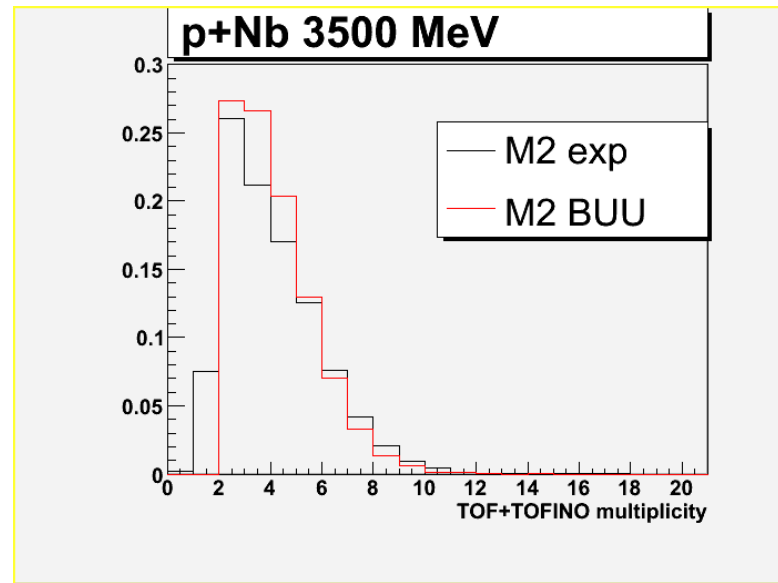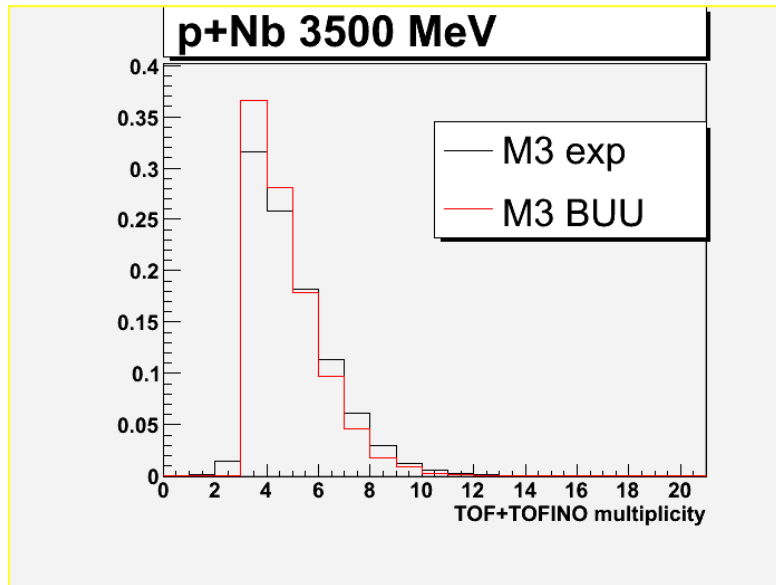# "Selfconsistency check" - UrQMD

UrQMD input (emitted) and its reconstruction by analysis

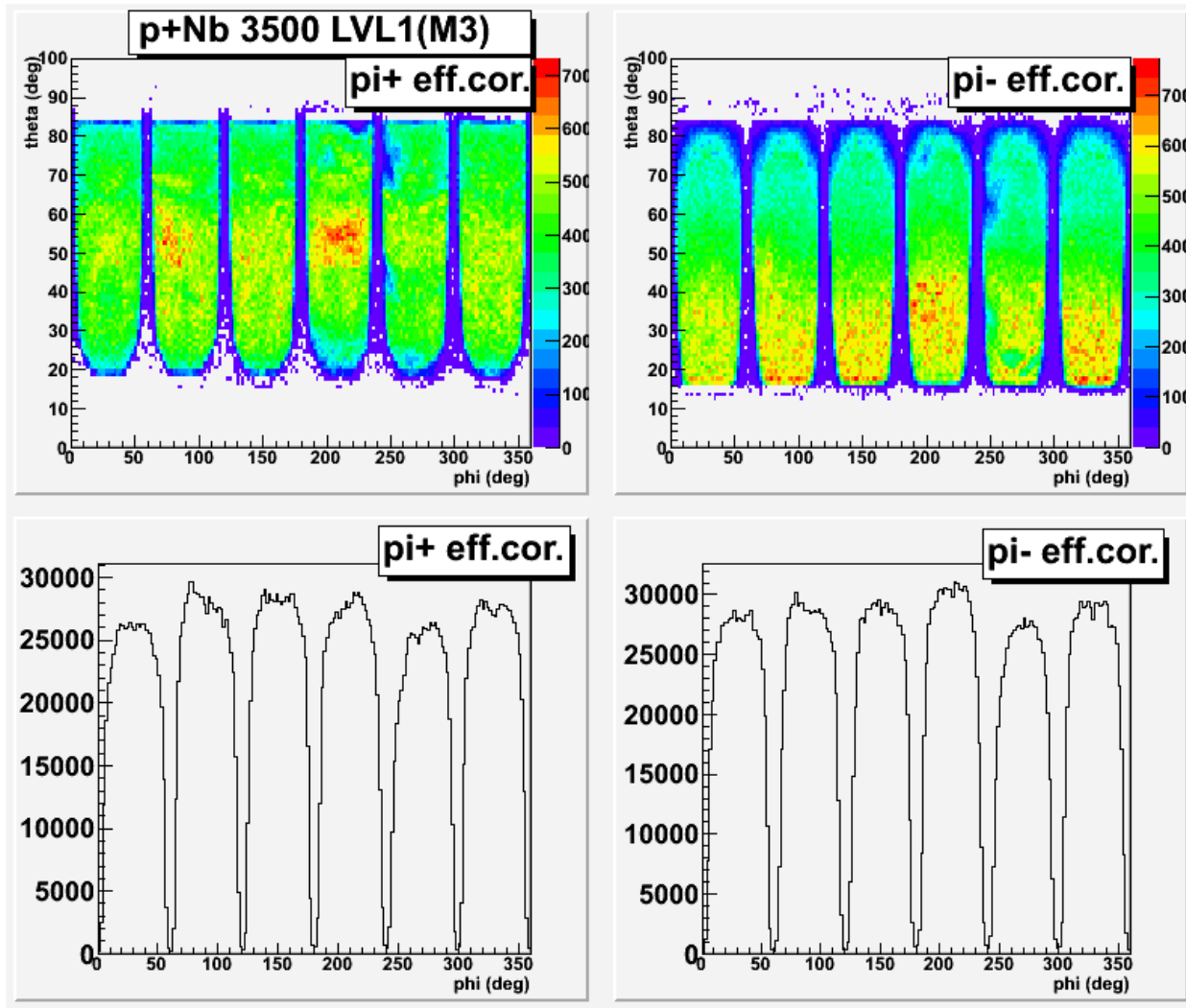# TOF+TOFINO and track multiplicities

TOF+TOFINO and track multiplicities

TOF+TOFINO and track multiplicities

- agreement between data and UrQMD multiplicities not very good

  better agreement M3 data – M4 UrQMD track multiplicity than for both M3,

  same for M2

  – makes precise correction on LVL1 bias difficult

- quite lot of events with no track. – Non-target interaction?

  from a comparison with Poisson distribution estimate of 17% and 23% of

  such events for M3 and M2, respectively, see figures on previous page

  (difference between expected and real countrate at track mult. 0)

  - such numbers used for pion multiplicities calculation

  - influences strongly the pion multiplicities

Theta vs phi distributions

Pt vs y distributions