Comparison of transport code results

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During the preparation of the workshop, J. Aichelin designed the attached benchmark test for the transport codes. The following theory groups replied by sending to me a lot of data and ps files:
Giessen (W. Cassing, E. Bratkovskaya),
SUNY (C.H. Lee, relying on G.Q. Li's code),
Nantes (J. Aichelin, C. Hartnack),
Frankfurt (S. Soff and collaborators, UrQMD),
Tuebingen (C. Fuchs),
Budapest (Gy. Wolf).
The results have been discussed in the Friday morning session. Here I try to give a compilation of a few comparisons. Note that the groups from Frankfurt, Tuebingen and Budapest focus on K^+ production.

1 Number of pions and deltas

The number of pions and deltas as a function of time is displayed in fig. 1. There are obvious differences in the zero points of time.

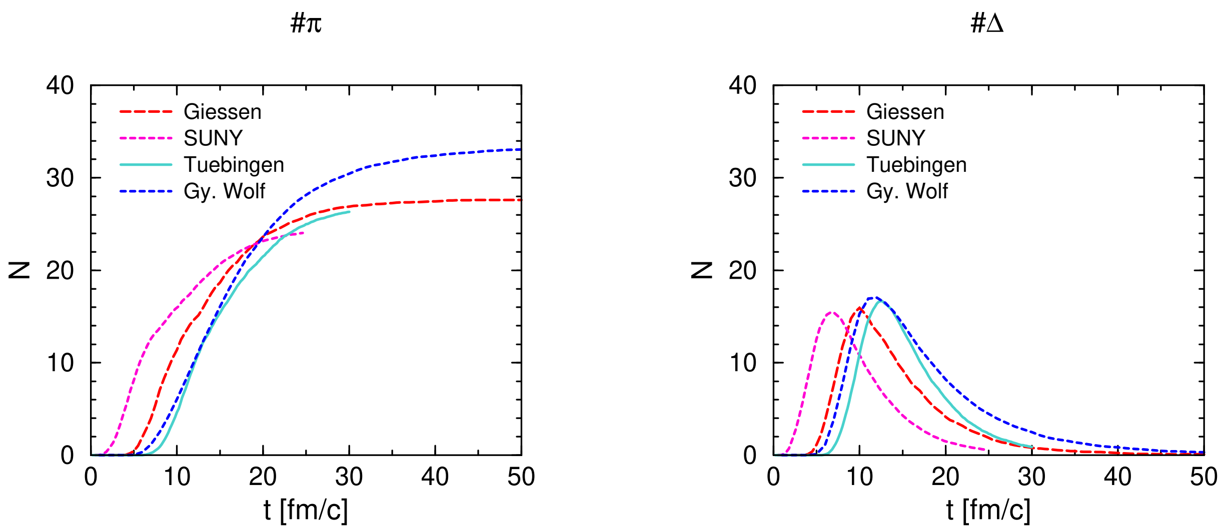


Figure 1: The number of pions (left panel) and deltas (right panel) as a function of time.

2 Elementary cross sections

The cross sections are displayed in figs. 2 – 28. Two groups (Frankfurt, Budapest) have parametrisations which describe quite accurately the older bubble chamber data and results from COSY-11 and COSY-ToF as well. A strong point has been made in the

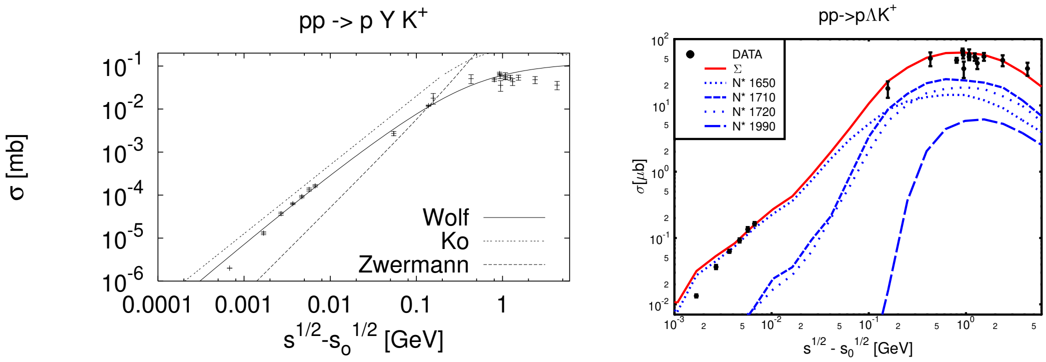


Figure 2: The cross section $pp \to p\Lambda K^+$ (left panel: Budapest parametrisation, right panel: Frankfurt parametrisation).

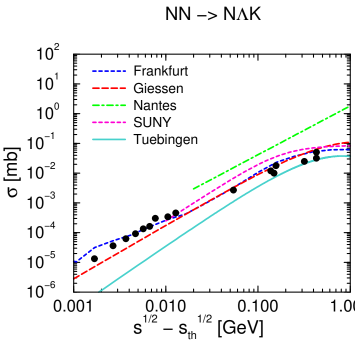


Figure 3: The cross section $NN \to N\Lambda K^+$.

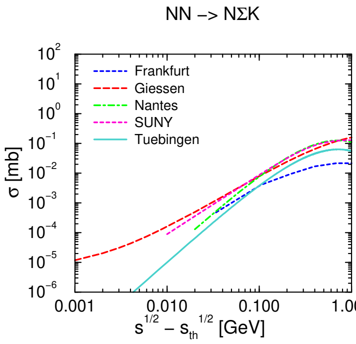


Figure 4: The cross section $NN \to N\Sigma K^+$.

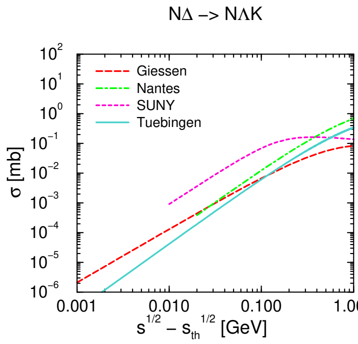


Figure 5: The cross section $N\Delta \to N\Lambda K^+$.

discussion by the Giessen group that it would be more appropriate to use the bare production cross sections by removing the final state interaction from the experimental data. The Giessen group is preparing such a parametrisation to be used in a second round of benchmark tests.

As seen in figs. 3 – 5 the elementary cross sections partially deviate noticeably. Reasons for these differences can be the following ones: consistency with previous stages of development of the codes, or compensation for other channels not included explicitly. Sometimes the authors told me that they use the cross sections "as every body", therefore they did not send data files for them. When I display data in the figures (fat dots) one should be aware that these correspond to pp reactions, while the elementary cross sections refer to isospin averages used in the codes. Due to the too large differences the groups agreed to rely on a unique parameter set in a second round of benchmark test.

The Tuebingen and Nantes groups additionally use the cross sections displayed in figs. 23 – 28 instead of the cross sections where in the exit channel a nucleon appears. The Nantes group did not send files for the πX reactions; a few selected points from their input are marked by crosses.

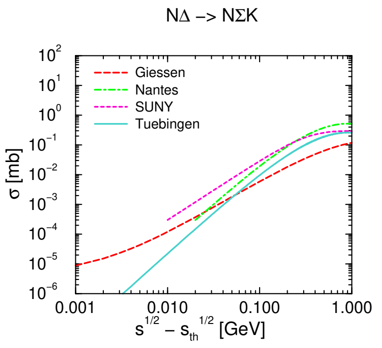


Figure 6: The cross section $N\Delta \to N\Sigma K^{+}$.

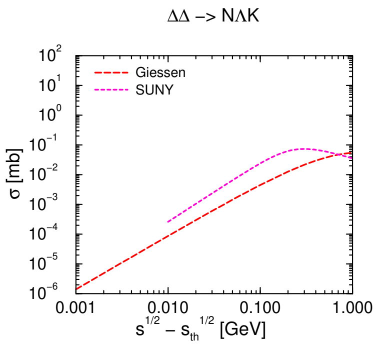


Figure 7: The cross section $\Delta\Delta \to N\Lambda K^{+}$.

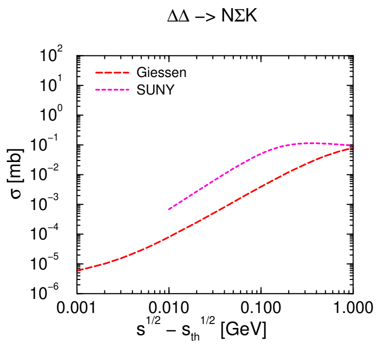


Figure 8: The cross section $\Delta\Delta \to N\Sigma K^{+}$.

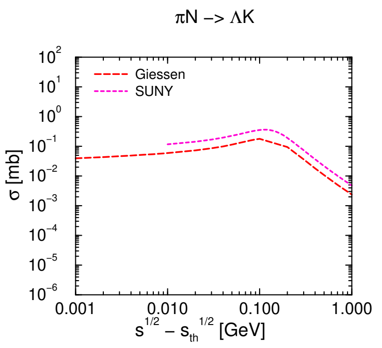


Figure 9: The cross section $\pi N \to \Lambda K^{+}$.

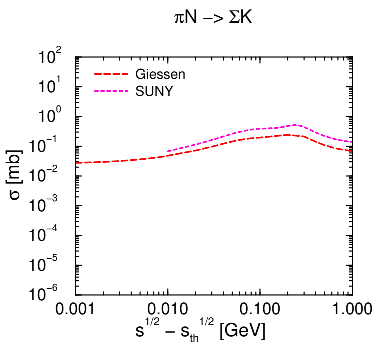


Figure 10: The cross section $\pi N \to \Sigma K^{+}$.

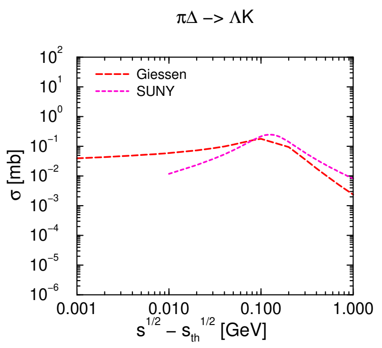


Figure 11: The cross section $\pi\Delta \to \Lambda K^{+}$.

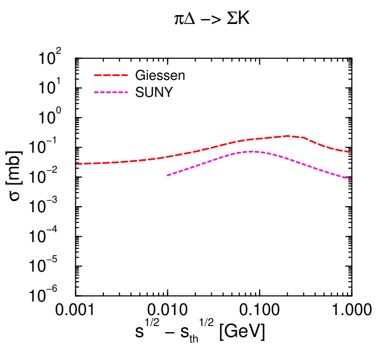


Figure 12: The cross section $\pi\Delta \to \Sigma K^{+}$.

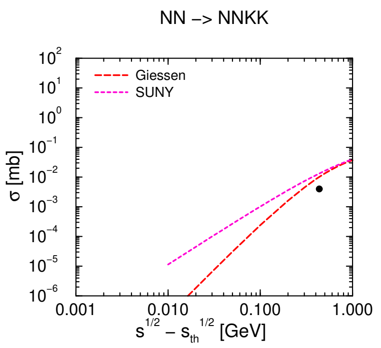


Figure 13: The cross section $NN \to NNK^{+}K^{-}$.

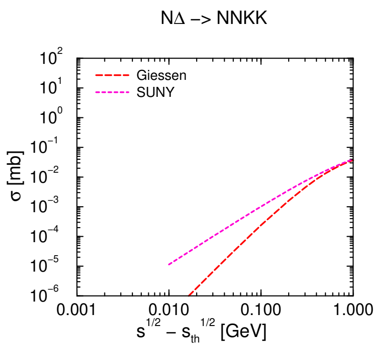


Figure 14: The cross section $N\Delta \to NNK^{+}K^{-}$.

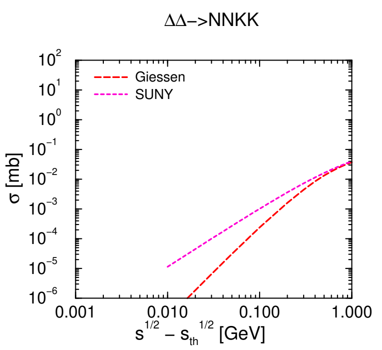


Figure 15: The cross section $\Delta\Delta \to NNK^{+}K^{-}$.

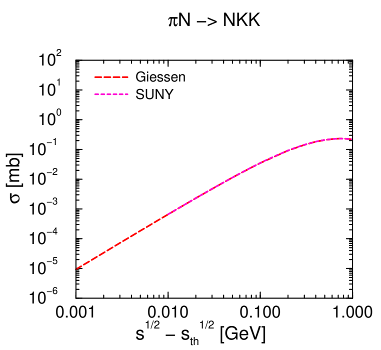


Figure 16: The cross section $\pi N \to NK^{+}K^{-}$.

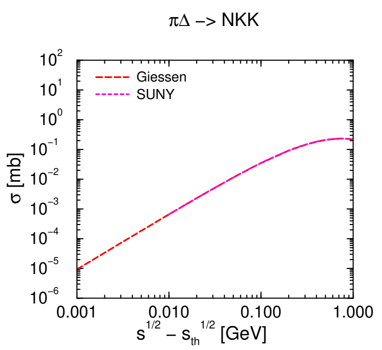


Figure 17: The cross section $\pi\Delta \to NK^{+}K^{-}$.

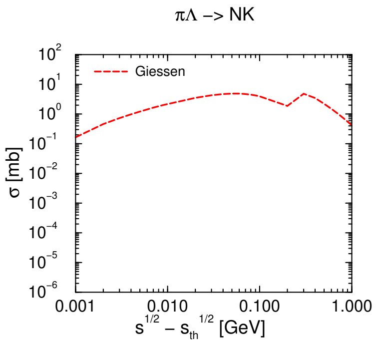


Figure 18: The cross section $\pi\Lambda \to NK^-$.

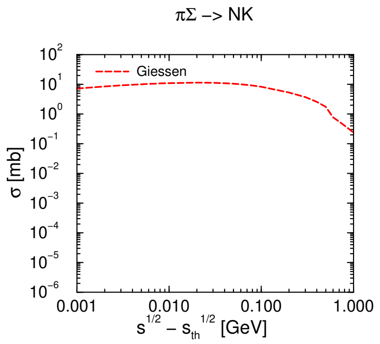


Figure 19: The cross section $\pi\Sigma \to NK^-$.

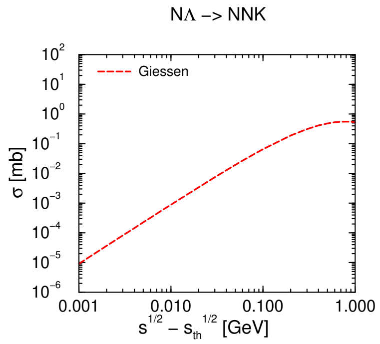


Figure 20: The cross section $N\Lambda \to NNK^-$.

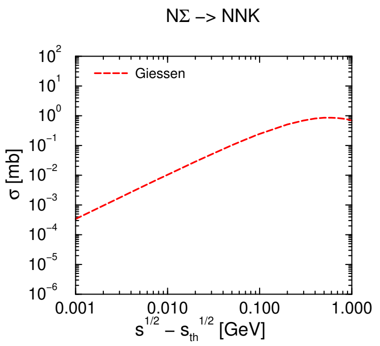


Figure 21: The cross section $N\Sigma \to NNK^-$.

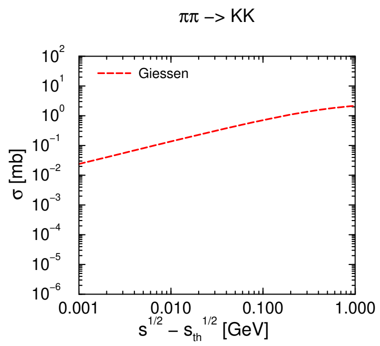


Figure 22: The cross section $\pi\pi \to K^+K^-$.

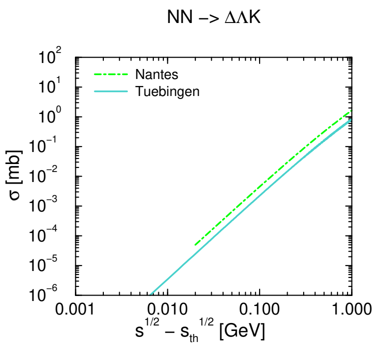


Figure 23: The cross section $NN \to \Delta\Lambda K^-$.

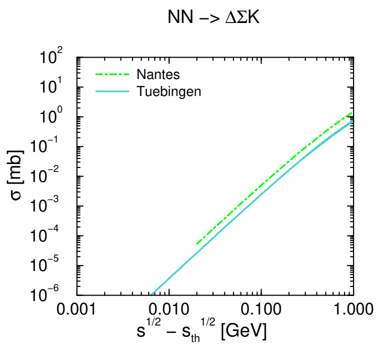


Figure 24: The cross section $NN \to \Delta\Sigma K^+$.

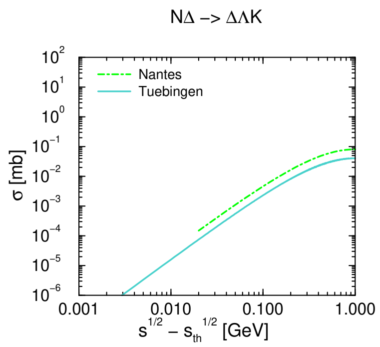


Figure 25: The cross section $N\Delta \to \Delta\Lambda K^+$.

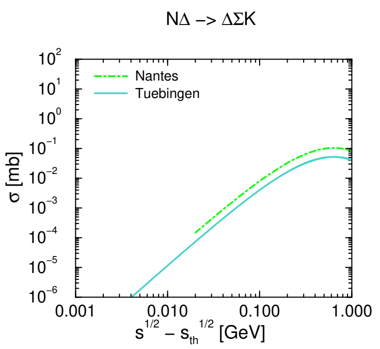


Figure 26: The cross section $N\Delta \to \Delta\Sigma K^+$.

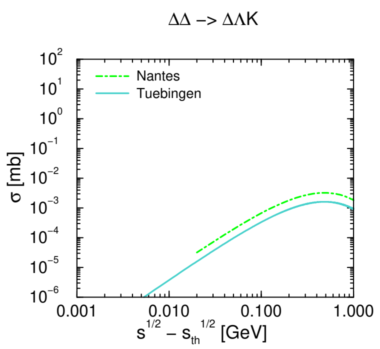


Figure 27: The cross section $\Delta\Delta \to \Delta\Lambda K^+$.

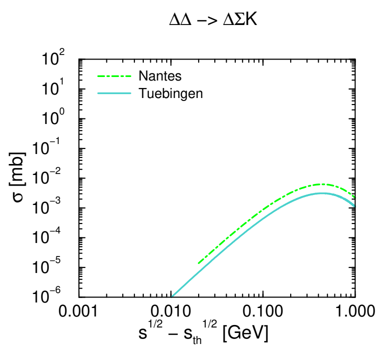
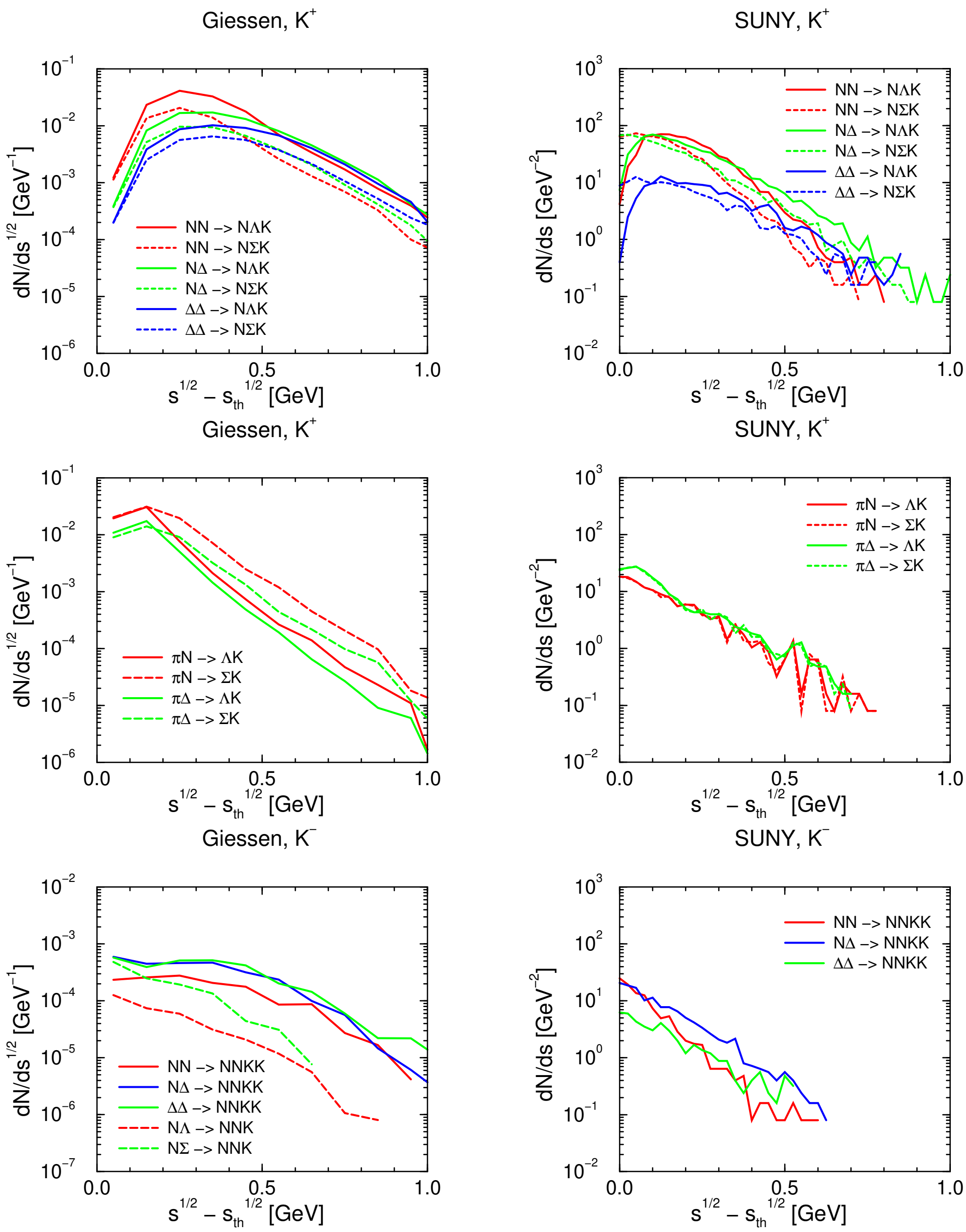


Figure 28: The cross section $\Delta\Delta \to \Delta\Sigma K^+$.

3 The distribution $dN/ds^{1/2}$

To see which channels contribute most significantly and which Q values above the corresponding threshold are most important one may inspect the distributions $dN/d\sqrt{s}$ as a function of $\Delta s^{1/2} = s^{1/2} - s^{1/2}_{thresh}$,displayed in fig. 29. One observes quite analog weights of the various channels ??? Dominating BB reactions contribute at $\Delta s^{1/2} \sim 300$ MeV in K^+ ($0 - 500$ MeV in K^-) production, while the πB channels have the tendency to peak at small values of $\Delta s^{1/2}$.



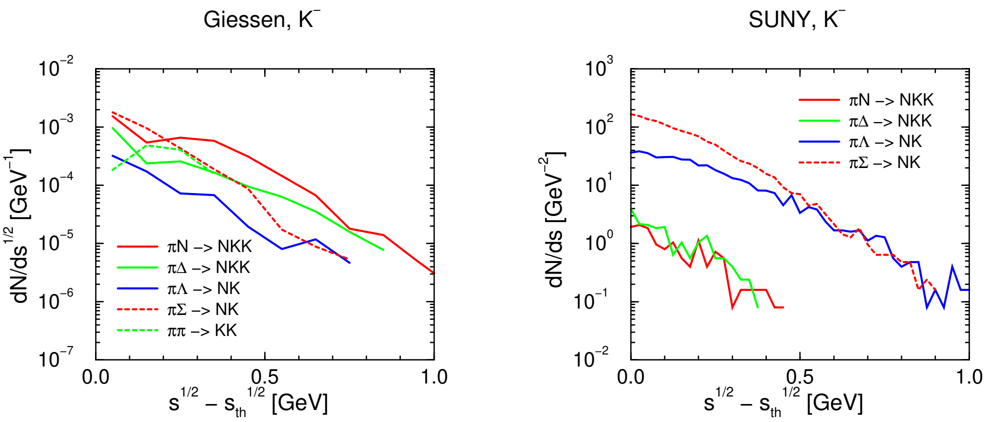


Figure 29: The distribution $dN/ds^{1/2}$ (left panel, Giessen) and dN/ds (right panel, SUNY [differently normalized]) as a function of $\Delta s^{1/2}$.

4 Nucleon flow

The overall nucleon flow and the flow of nucleons involved in kaon production are displayed in fig. 30. The Giessen group communicated that that their nucleon flow results are successfully compared in detail with the FOPI data; in this respect the nucleon flow of other groups seems somewhat too large.

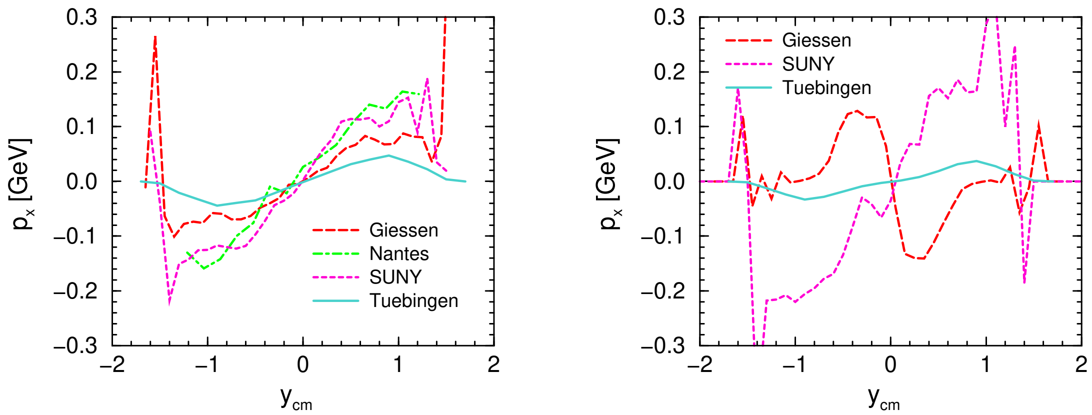


Figure 30: The overall nucleon flow (left panel) and the flow of nucleons involved in kaon production (right panel; the results of the Giessen group are for instant of kaon production, while the groups report results for the final nucleon flow).

5 Rapidity distributions

5.1 At production

The rapidity distributions of bare kaons just in the moment of production are displayed in figs. 31 and 32. Here the summed curves for BB (i.e. baryon-baryon) and MB (i.e. meson (π)-baryon channels are displayed. One observes here significant differences, which propagate through the following figures too.

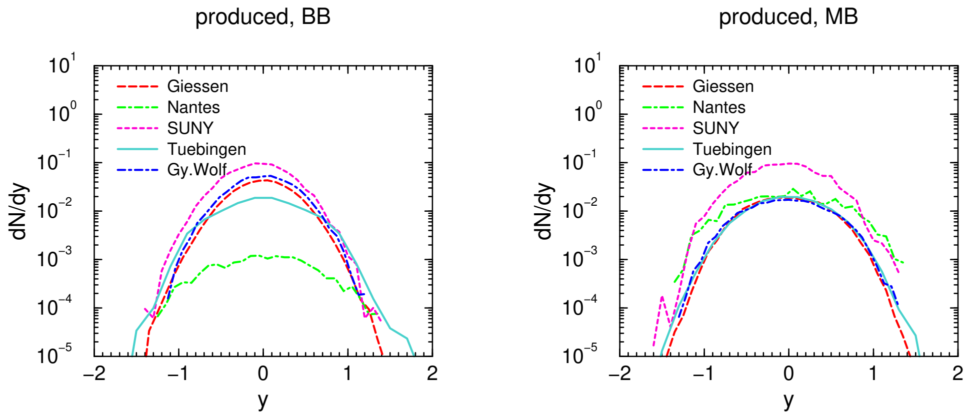


Figure 31: Bare K^+ rapidity distribution at production.

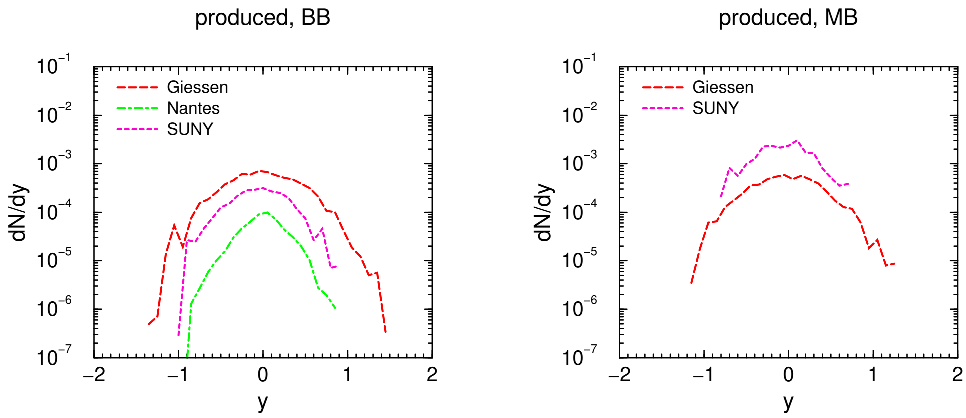


Figure 32: Bare K^- rapidity distribution at production.

5.2 Final distribution

The final rapidity distributions of kaons (with rescattering and in-medium effects) are displayed in figs. 33 and 34.

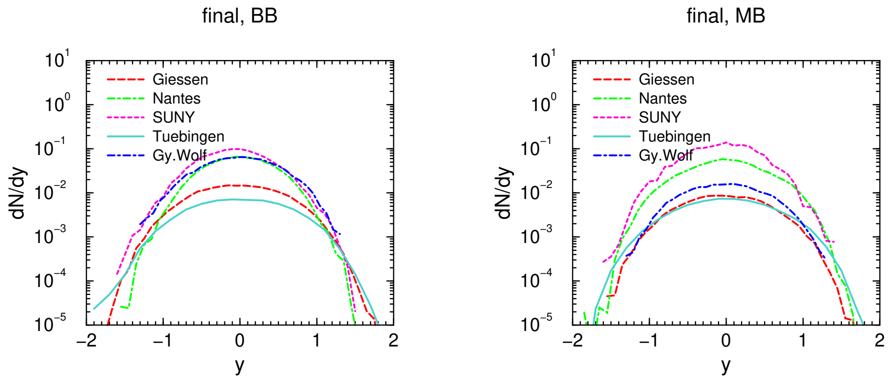


Figure 33: Final K^+ rapidity distribution.

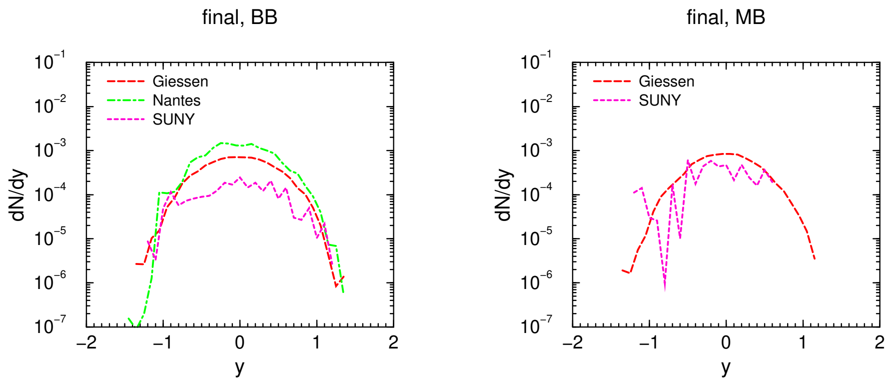


Figure 34: Final K^- rapidity distribution.

6 Transverse momentum distributions

6.1 At production

The transverse momentum distributions of bare kaons at production are displayed in figs. 35 and 36.

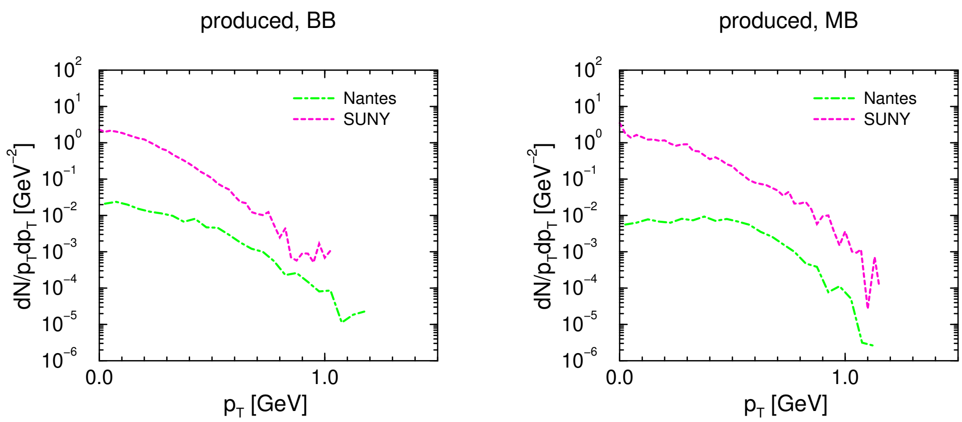


Figure 35: Bare K^+ transverse momentum distribution at production.

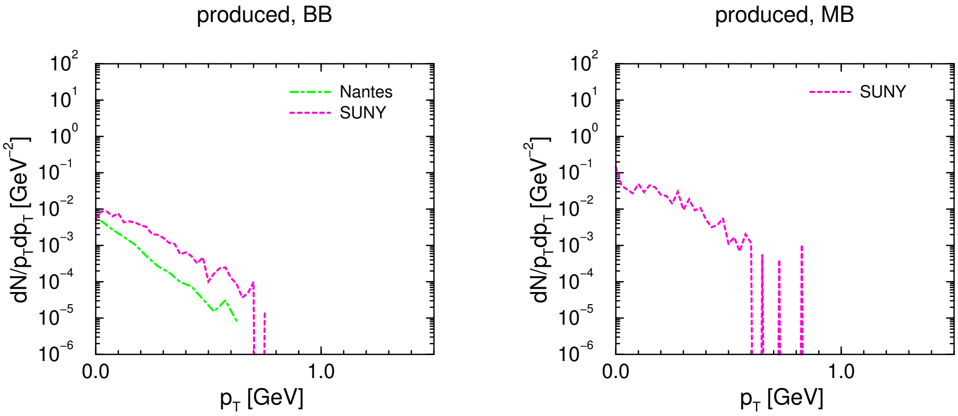


Figure 36: Bare K^- transverse momentum distribution at production.

6.2 Final distribution

The final distributions of kaons (with rescattering and in-medium effects) are displayed in figs. 37 and 38.

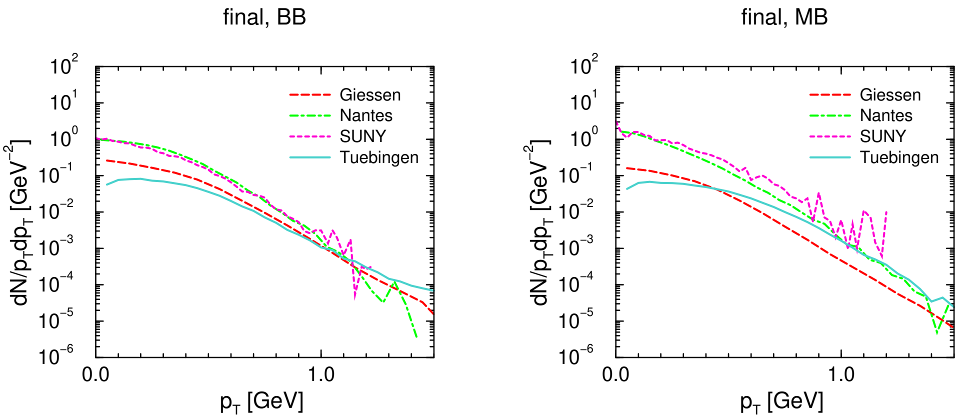


Figure 37: Final K^+ transverse momentum distribution.

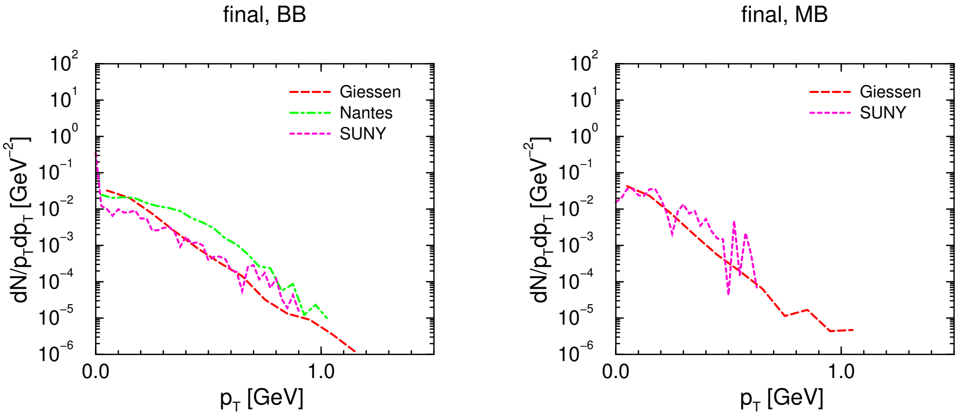


Figure 38: Final K^- transverse momentum distribution.

7 Laboratory transverse momentum distributions

The final laboratory transverse momentum distributions for $\Theta_{lab} = (44 \pm 6)^o$ are displayed in figs. 39 and 40 (with rescattering and in-medium effects).

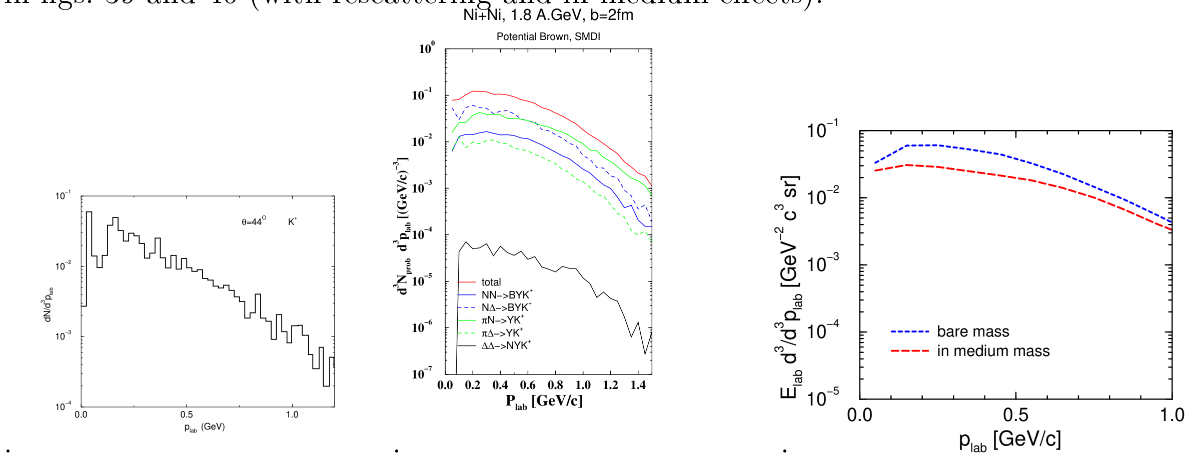


Figure 39: Final K^+ transverse momentum distribution in the lab system (SUNY, Tuebingen, Giessen from left to right; the results are obviously differently normalized).

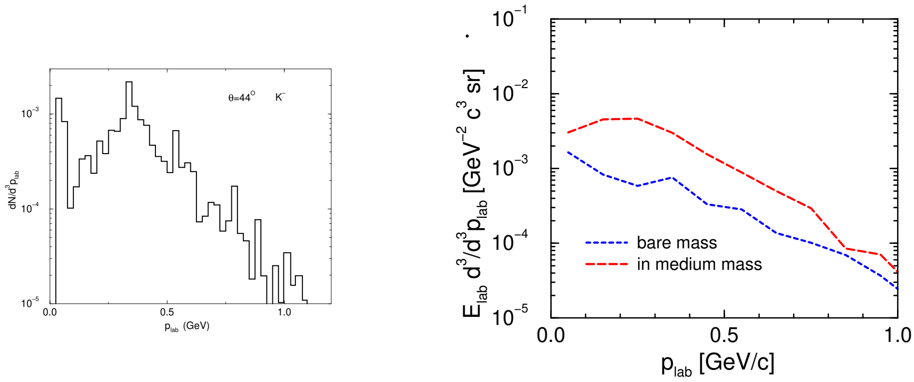


Figure 40: Final K^- transverse momentum distribution in the lab system (left [right] panel: SUNY [Giessen]; the results are obviously differently normalized).

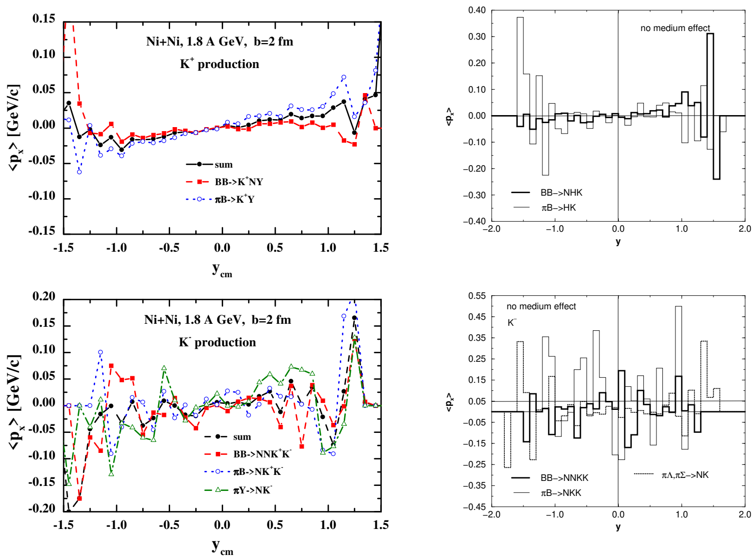


Figure 41: Bare $K^\pm$ flow at production (left [right] panels Giessen [SUNY]).

8 Kaon flow

Results of the kaon flow are displayed in figs. 41 and 42.

9 Concluding remarks

This is a rough survey on a part of results I received from the active groups. There are obvious differences which must be discussed and clarified in a second round of test calculations relying on a unique input (elementary cross sections).

I hope that in the process of a unifying representation I did not mess up too many data. In a few places one observes obvious different normalizations employed; in a few cases I was asked to scale up/down some contributions and I tried to do so or to indicate in the figure captions these desires.

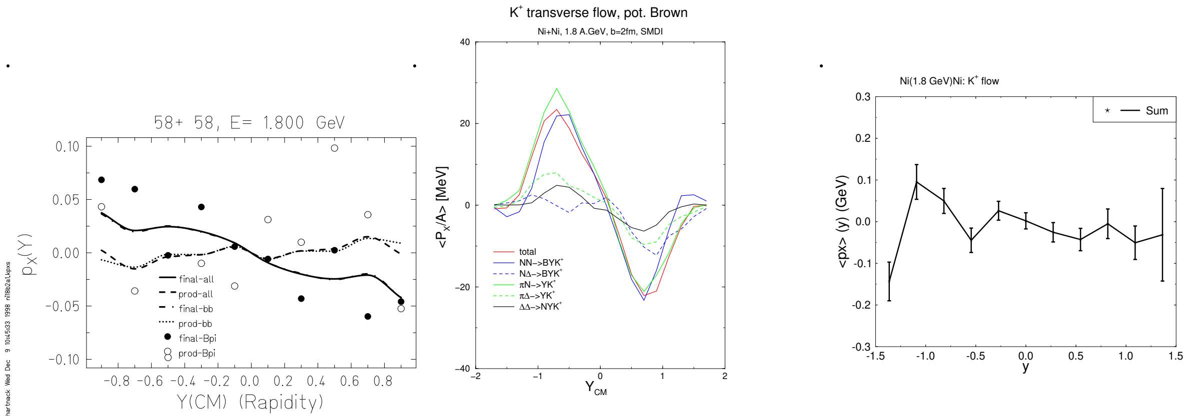


Figure 42: Final K^+ flow (Nantes, Tuebingen, Frankfurt).

Big efforts have been made by the participating groups, and the workshop organizers are grateful to all activists for their attempts. I thank K. Gallmeister for assisting me in the preparation of the figures.

Attachment