DATABASE ON THE NET FOR PARTICLE CORRELATIONS
AND SPECTRA

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A fully interactive database is presented, which provides user-friendly access to experimental results on single-particle spectra and two-particle correlations (particle interferometry or HBT-effect). The database is available on the World-Wide-Web at: http://www.quark.lu.se/~janus/hbt_home.html.

1 Idea of and Motivation for the Database

A fully interactive database could make the access to the detailed experimental data more efficient than just looking up the data (figures, functions or tables) in scientific journals. We report here about the creation of such a database, where the experimentally determined parameters can be archived, together with the experimentally measured distributions, using the framework of the presented database. Additional information including pictures, links to related papers, PAW kumac files etc. could be stored together in such a searchable database. It is based on a user-friendly environment and is easily accessible through the Internet.

In general, the structure of the database is quite generic and its potential is in no way restricted to a certain type of data. In particular, we started the creation of this database in order to prepare a catalyst for a more detailed communication between experimentalists and theoreticians working in the field of particle correlations and spectra.

2 Definitions

There has been recently a substantial increase in the number of publications related to the study of two-particle correlations in the field of high-energy heavy-ion physics. Short-range correlations of various pairs of elementary particles yield information on the space-time extent of the region which produces
particles with a given momentum in high-energy collisions. Recently, it became clear that a simultaneous analysis of two-particle correlations and single-particle spectra may yield some clues about the full size of the interaction region (core), about the flow, the density and the temperature profiles.\textsuperscript{1,2,3,4,5} Further, the two-particle correlation function has been experimentally analyzed in a more and more sophisticated manner.\textsuperscript{6,7,8,9} The two-particle correlation function is defined as

\[ C(\Delta \mathbf{k}, \mathbf{K}) = \frac{\langle n \rangle^2}{\langle n(n-1) \rangle} \frac{N_2(p_1, p_2)}{N_1(p_1)N_1(p_2)}, \]

where $\langle n \rangle$ is the mean multiplicity, $\langle n(n-1) \rangle$ is the second factorial moment of the multiplicity distribution, $N_2(p_1, p_2)$ is the two-particle inclusive invariant momentum distribution, $N_1(p_1)$ is the single-particle inclusive invariant momentum distribution (IMD) or single-particle spectrum, $p_1$ stands for the three-momentum of particle 1, the relative momentum is denoted by $\Delta \mathbf{k} = p_1 - p_2$ and the mean momentum is denoted by $\mathbf{K} = 0.5(p_1 + p_2)$.

The invariant momentum distribution (IMD) for a given type of particle stands for the (single - or two-particle) inclusive invariant momentum distribution,

\[ N_1(p) = E \frac{dN}{dp} = \frac{E}{\sigma_{\text{tot}}} \frac{d\sigma}{dp}, \]

\[ N_2(p_1, p_2) = E_1E_2 \frac{dN}{dp_1dp_2} = \frac{E_1E_2}{\sigma_{\text{tot}}} \frac{d\sigma}{dp_1dp_2}, \]

where $\sigma_{\text{tot}}$ is the total inelastic cross-section. It is assumed that particles 1 and 2 are identified and some kind of effective final-state interaction creates short-range correlations between them. For identical particles, such short-range correlations may arise due to Bose-Einstein or Fermi-Dirac statistics, for charged particles due to the Coulomb interaction, and for strongly interacting particles due to strong final state interactions. Most frequently correlations between identical particles are studied. Recently, a systematic study of short-range correlations was reported by W.A. Zajc at the HBT’96 conference,\textsuperscript{10} which investigated the correlations between pions, kaons and protons in any pair-combination, including particles and anti-particles.

The two-particle correlation function depends in general on 6 independent momentum components. Currently, advanced measurements attempt to determine this correlation as a function of 5 variables, assuming azimuthal symmetry.\textsuperscript{8} Preliminary data are becoming available for 6 dimensional correlation functions, too.\textsuperscript{11} A correlation function of order $j$ depends in general on
These data are then analyzed in terms of simple parameterizations and only the fitted parameters are published in a number of cases. However, the measured higher-order distributions are frequently not available for the scientific community. E.g., very few two- or three-dimensional two-particle correlation functions are published in the literature, although a lot of parameterizations are published for these reactions. Similarly, the present practice of publishing measured single-particle spectra relies frequently on the publication of the slope parameters of the invariant momentum distribution, or on the measurement of the rapidity distribution. Recent theoretical developments and also recent measurements suggest that the spectrum is not factorizable, the rapidity and the transverse-mass dependence is coupled. Thus, at least the two-dimensional $\frac{dn}{m_t dm_t dy}$ distributions should be published. The conventional form of scientific publications may utilize long tables published in refereed journals to achieve such a goal. However, we would like to provide an additional method to reach the same purpose by the creation of the HBT and Spectrum database, to which the experimental collaborations can submit (or upload) data. The possibilities of electronic publishing can be exploited by the usage of such a database.

Thus, the HBT and Spectrum database provides a framework for the publication of one- or multi-dimensional distributions, in order to make the measured data points accessible electronically for the interested parties in an easy-to-use manner. Submitters to the database should be registered and should provide their e-mail address before they can get an automatically generated password which will be needed for submitting data to the database. (Of course, no password is requested from those who would like to download the data). Upload of files is also possible to provide pictures of the data and to make full distributions available for the interested scientific community. Some data are already available in a demo version of the database - we suggest that you consult this demo before actually starting the transmission. A brief on-line documentation is also provided and the list of members or submitters to the database can be seen interactively.

3 Responsibilities

In order to give experimentalists full responsibility for their data, they are supposed to submit the data themselves. This can be done by making a fully interactive database. Also, published and preliminary data should be clearly separated. Published data are supposed to be fully corrected for known experimental errors, the measured values and their statistical and systematic errors are determined by the collaborations and published in refereed scientific jour-
Figure 1: The picture shows how the HBT and Spectrum database appears on the Internet when a Netscape browser is utilized. HBT (Hanbury-Brown – Twiss) stands for correlation functions, while IMD denotes single-particle inclusive invariant momentum distributions or particle spectra. The location of the page (WWW URL) is visible in the upper part of the picture: http://www.quark.lu.se/~janus/hbt_home.html. Note that www.quark.lu.se and hurtig.quark.lu.se refer to the same address.
nals. On the other hand, sometimes it takes years until all the corrections and errors of the measurements are understood, and some data are presented at conferences as the Quark Matter conference series\(^8\) in a preliminary form. Such data are very useful to guide the development of theoretical descriptions. However, they should not be confused with fully corrected published data. In order to avoid such a case, the database clearly distinguishes preliminary and published data, which could be submitted and retrieved separately both for HBT and IMD data. Submitters and users of preliminary data are supposed to agree on the terms of the usage of preliminary data. After some discussions with our experimental colleagues, the following Agreement Form has been prepared: “These data are supposed to be presented to the scientific community at some conferences and/or other scientific meetings, however they are not supposed to be final or fully corrected. Submission to the database of preliminary data implies that the submitter/experiment agrees to a broad distribution and discussion of their preliminary data, under the condition that the data are discussed as preliminary ones. Any user of the preliminary data is supposed to refer to these data as preliminary, i.e. not final data. The manager of the database is not responsible for any problems with the preliminary data, all responsibility to communicate correct research rests with the submitters and the users of the database.”

The database is fully interactive, which implies that the original submitter can edit or modify the submissions. The submitter can edit/delete the data submitted by him/herself at any time. A log file is created together with the submission, which is updated each time the submitted material is edited.

4 Technical Description

Utilization of a program language inside a HTML document (PHP/FI ver. 2.0) together with a database program (mSQL including a special interface W3-mSQL) made it possible to use the World-Wide-Web as interface between the user and the database. This ensures the requested user-friendly and easily accessible environment. The preferable net-browser is Netscape, which supports FRAMES and FORMS. According to a recent estimate, a Netscape browser is utilized in more than 80 % of Internet explorations. The browsers NCSA Mosaic or Microsoft Explorer are also supported, but their usage results in a less advanced performance.

Open the location http://www.quark.lu.se/~janus/hbt_home.html in order to contact the database. Here one finds a menu where one can either have a look at the database (presently separated into four parts, namely HBT and IMD for published and preliminary data, respectively) or submit data.
In order to submit data one must register as a user. By doing this one will receive a password via e-mail. The submission includes: Name, title of paper, www-link to paper, author, submitted when to whom, links to other papers and to the home page of the submitter, abstract, notes about the data, results in a table which can be customized and kumac-, picture- and data-file upload (more about this below). The submitted data is sorted according to beam energy, beam particle and type of particle measured.

5 Format for Data and Picture Files

It is possible to upload ASCII and GIF files to this database. The ASCII datafile should preferably include as complete information about the data as possible, for example the raw data set together with errors, various corrections, errors of corrections, and the fully corrected data set together with systematic and statistic errors. Such a policy is recommended in order to allow for new developments in the correction for the systematic errors on the data. For example, Coulomb corrections to measured two-particle correlation functions can be performed utilizing different methods\textsuperscript{10,12} and new methods for the Coulomb corrections can only be tested if the uncorrected data were available.

Below each data file further information should be included, like: colliding system, beam energy, acceptance, trigger condition, particle id definition, 2 particle cuts/corrections, kinematic cuts, reference frame, fit function, fit parameters and errors, correlation contours for parameters and anything else that could be useful for the user to know.

5.1 Format of an ASCII data file containing particle spectra

It is very important for the use of the database, that also data points for the fitted double-differential invariant momentum distributions and correlation functions will be available. This permits the performance of a more advanced analysis than just to describe the fitted parameters of the data.

The format of the ASCII-file for the IMD or spectrum is indicated on Table 1.

In Table 1, $p_i$, $i = 1, 2, 3$ could be any momentum component, e.g. $p_x$, $p_y$, $p_z$ in MeV, or, alternatively, the rapidity and transverse mass, $y = 0.5 \log((E + p_z)/(E - p_z))$ and $m_t = \sqrt{m^2 + p_x^2 + p_y^2}$, or a sub-set of the above. Some comments appended to the end of the data file should specify the definitions and the units of the momentum variables. If not all the information listed above is available, a fraction of it could be submitted, too.
From time to time, new expressions appear in the literature which can describe the measured distributions in greater detail than the previously preferred formulae. A well-known example for such a behavior is the out-long cross-term in the two-particle correlation function, another important but not so well-known example is the appearance of an \( m_t \) dependent effective volume factor in the single-particle spectra, which suggests that the particle spectra should be fitted with an expression

\[
N(p) = C m_t^\alpha \exp(-m_t/T_*(y)),
\]

where \( \alpha \) is a new free fit parameter, the effective-slope parameter \( T_* \) should depend on the rapidity \( y \) and \( C \) stands for a normalization constant. Previously, data were frequently fitted with the above expression utilizing a fixed value of \( \alpha = 0 \) or \( \alpha = 0.5 \). Because of this and similar reasons, we would like to encourage the experimentalists to submit not only the fitted parameters but also the measured distribution functions themselves to the database, in as detailed a manner as possible.

### 5.2 Format of ASCII File for Data on Correlations

The following format is recommended for ASCII-files containing correlation functions:

Table 2. Data structure for the correlation functions

| \( Q_1 \) | \( Q_2 \) | \( Q_3 \) | \( A(Q) \) | \( \delta A(Q) \) | \( B(Q) \) | \( \delta B(Q) \) | \( C_u(Q) \) | \( \delta C_u(Q) \) | \( C(Q) \) | \( \delta C(Q) \) |
|---|---|---|---|---|---|---|---|---|---|---|
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

Comments: \( Q_1 = Q_{\text{inv}}, \ldots \), Ref: Phys. Rev...

In Table 2, \( Q = (Q_1, Q_2, Q_3) \) could be \( Q = (Q_{\text{long}}, Q_{\text{side}}, Q_{\text{out}}) \) at a fixed value of \( K \) for a 6-dimensional distribution, or \( Q = Q_{\text{inv}} \) for a one dimensional distribution. (In the latter case the second and third columns of the above table
should of course be missing or left empty). See e.g. refs. $^6,^7,^9$ for the definitions of the components of the relative momentum. The relative-momentum components are to be specified in some comments appended to the end of the data file, and a statement about the allowed region for the mean momentum of the particles should be included with this comment, too. For a given value of the relative and mean momentum, we recommend submitting the Actual distribution of the particle pairs $A(Q)$, the Background distribution $B(Q)$, their errors $\delta A(Q)$ and $\delta B(Q)$, respectively, the uncorrected correlation function $C_u(Q) = A(Q)/B(Q)$, its error $\delta C_u(Q)$ and, finally, the fully corrected correlation function $C(Q)$ and its error $\delta C(Q)$. If the full information listed above is not available in full details, a subset could be submitted, too.

The ASCII data file together with the picture file of possible graphs should be submitted utilizing the submit menu from the home page of the Correlations and Spectra database:
http://www.quark.lu.se/~janus/hbt/scripts/upload.html.

6 Future

The development of the World-Wide-Web is fast and the possibilities are growing almost exponentially. The database will be updated regularly and suggestions for modifications or applying additional features will be taken seriously. The structure of the database is quite general, which allows for straight-forward extensions to include other type of data in case of future interest.

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