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A.G.Soloviev*

WASP (WAVELET ANALYSIS OF SECONDARY PARTICLES ANGULAR DISTRIBUTIONS) PACKAGE. VERSION 1.0. USER'S GUIDE

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*E-mail: solovjev@cv.jinr.ru

Introduction

WASP package is a C++ program aimed to analyse angular distributions of secondary particles generated in nuclear interactions. (WASP is designed for data analysis of the STAR and ALICE experiments). It uses a wavelet analysis for this purpose and the vanishing momentum or gaussian wavelets are choosen for transformations [1].

WASP provides an user-friendly Graphical User Interface (GUI) which makes it qiute simple to use. Both visualisation and GUI are implemented by using some ROOT classes. So, WASP requires ROOT [2] to be installed first. However, WASP classes, that are not corresponding to visualisation or GUI, are ROOT-independent.

WASP design, a briff description of the used wavelet transformation algorithm and GUI are represented in this user's guide.

1 Design

Design of WASP is presented in UML notation (see [3] for detales). The use case diagram, classes diagram and collaboration diagram are given in this section.

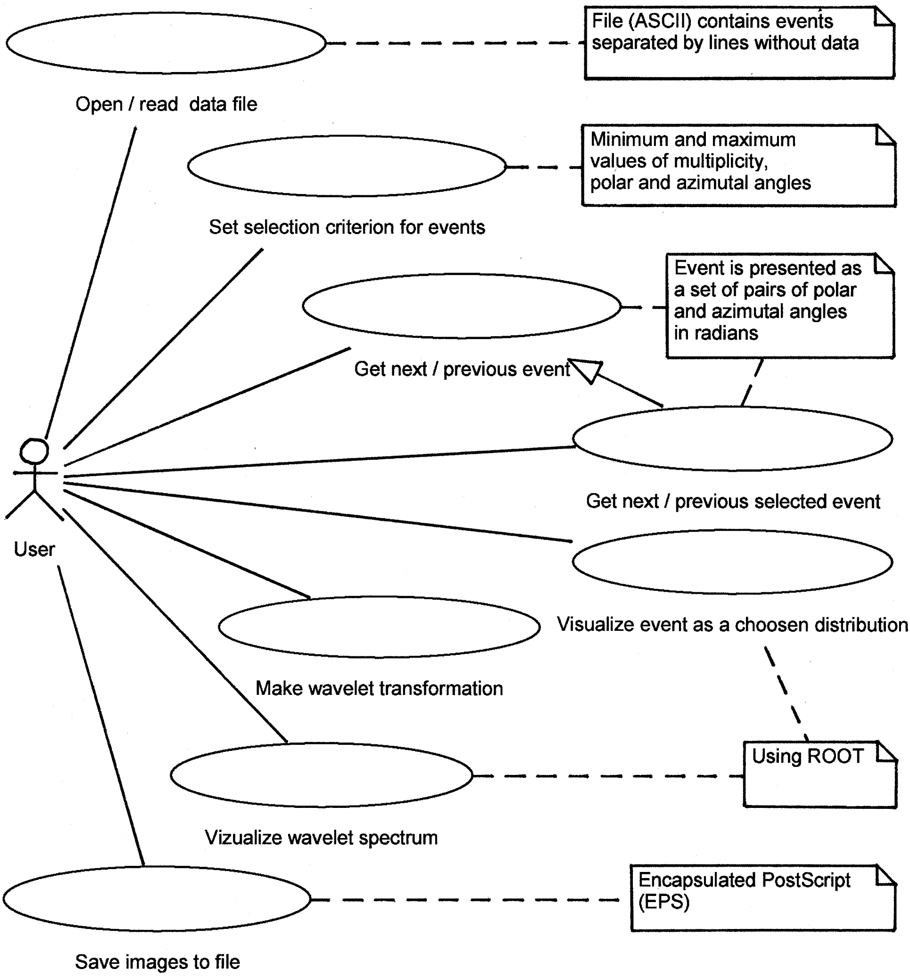

Fig. 1: Use case view

1.1 Use case view

The behaviour of WASP from an user point of view and user reguirements to it are represented by the use case diagram in fig. 1.

WASP allows one to read an event (a set of pairs of polar and azimutal angles in radians) from ASCII data file and to present it as a histogram of a choosen type. One can set a selection criterion for events to omit ones that are not interesting. WASP makes a wavelet transformation using a choosen gaussian wavelet at a choosen scale or at a range of scales and visualizes the obtained wavelet spectrum. As shown on fig. 1, the user can save the raw event and the wavelet spectrum images to files (in EPS format) and dump the wavelet spectrum to an ASCII file as a matrix.

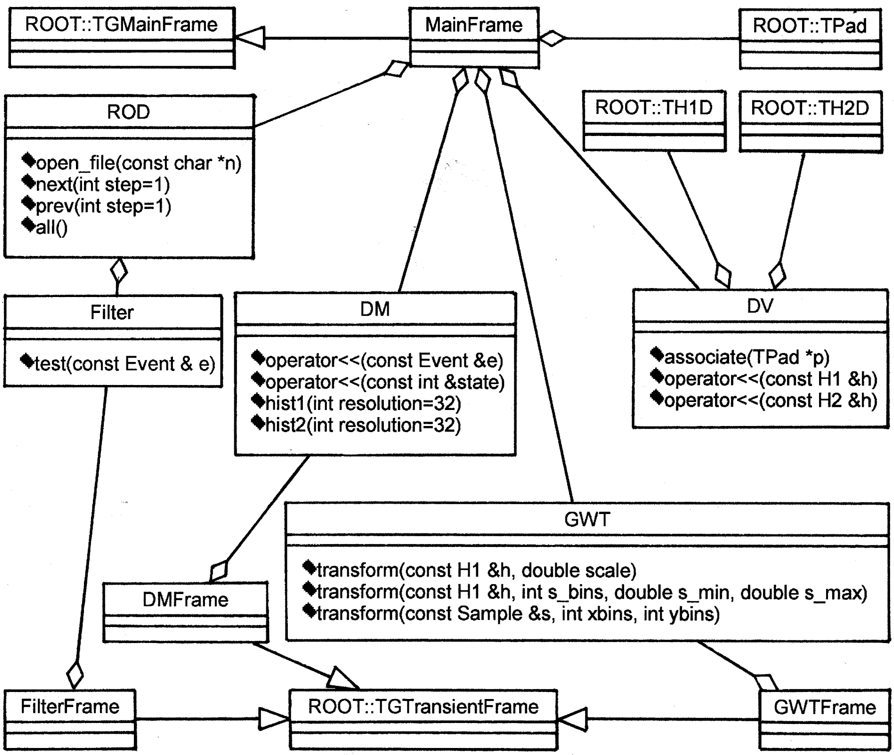

Fig. 2: Design view

1.2 Design view

WASP classes are represented by a classes diagram on fig. 2.

WASP own classes are: ROD (Read-Out Driver), DM (Distributions Maker), GWT (Gaussian Wavelet Transformer) and DV (Distributions Viewer). Moreover, Event, Filter, H1 (1D-histogram), H2 (2D-histogram) and several other classes are designed for convenience.

The implementation of the ROD methods `next(int step=1)`, `prev(int step=1)` and `all()` implies the following input file format. The file is read lile-by-line. If the line contains at least two numbers, the first of them is interpreted as a polar angle in radians, the second one — as azimutal angle in radians (moreover, it is transformed to be in $[0, 2\pi]$ if necessary), the rest of the line is ignored. Other lines are interpreted as event separators.

WASP uses some ROOT GUI classes for its own GUI, TH1D and TH2D ROOT classes for visualisation.

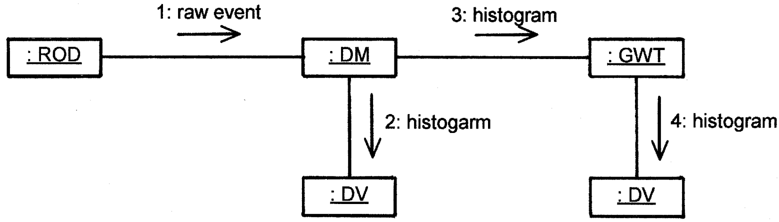

Fig. 3: Data Flow

1.3 Data Flow

A data flow, organized by WASP, is shown as a collaboration diagram on fig. 3. A raw event is transferred by a ROD object from input (std::istream) to a DM object. (ROD is able to make a raw event selection with the help of its data-member of the Filter type.) The DM object transforms the raw event to a histogram of a choosen type. This histogram can be visualized by means of puting it into a DV object. A GWT object transforms a source histogram (1D) to the wavelet spectrum histogram (2D) and the latter can also be visualized by puting it into the DV.

2 Gaussian Wavelet Algorithm

The wavelet transform of a signal $f(x)$ is determined as

$$W_\psi(a,b)f = \frac{1}{\sqrt{C_\psi}} \int\limits_{-\infty}^{\infty} \frac{1}{\sqrt{|a|}} \psi\left(\frac{b-x}{a}\right) f(x)dx \ , \tag{1}$$

(see [1]), where C_ψ is a normalizing constant, $\psi(x)$ is a wavelet, a is a scale.

For the discretized signal

$$f(x) = \frac{1}{N} \sum_{k=1}^{N} \delta(x - x_k) \ , \tag{2}$$

(1) is written as

$$W_\psi(a,b)f = \frac{1}{N} \frac{1}{\sqrt{|a|}} \sum_{k=1}^{N} \frac{1}{\sqrt{C_\psi}} \psi\left(\frac{b-x_k}{a}\right) \ , \tag{3}$$

and it looks like the Parsen–Rozenblatt estimates of the unknown probability density over a sample (see [4]). (3) is nothing but the "averaged sum" of the wavelets $\psi\left[(b-x_k)/a\right]/\sqrt{C_\psi}$ compressed to the size a and "placed" at points x_k.

The formula (3) does not contain integral and this fact allows one to speed-up the wavelet tarnsform algorithm for discretized signals like (2). Thus, (3) is just what is used in WASP for the wavelet analysis.

3 Graphical User Interface

To get started, just type `wasp` in your command line (WASP is to be installed, of course). WASP main window (see fig. 4) appeares. It has two panels. The raw event is visualized as a simple histogram on the left, the corresponding wavelet spectrum is shown on the right.

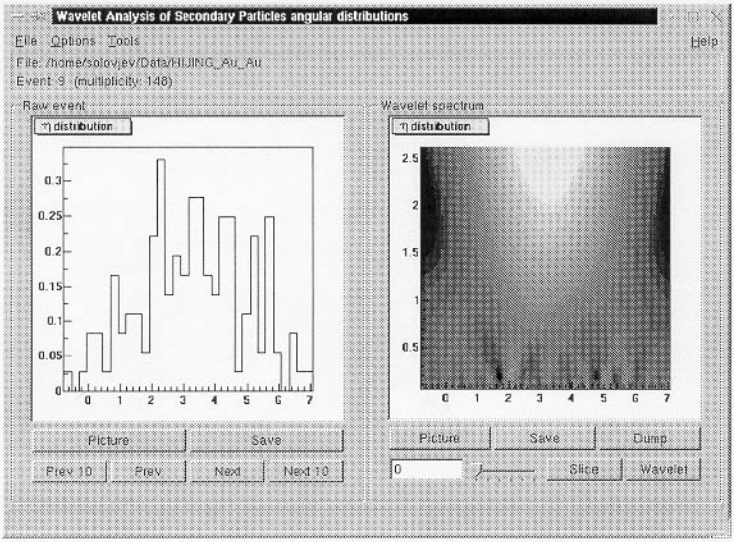

Fig. 4: Main Window

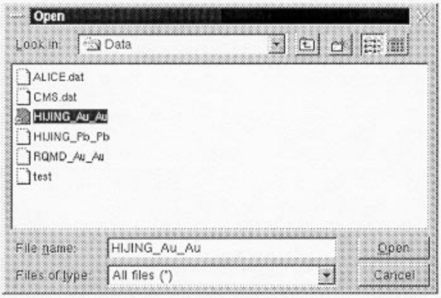

Fig. 5: File Open Dialog

Click the **Open** item in the **File** pop-up menu to choose input data file (see fig. 5). The **Reopen** item in this menu allows one to open the same file again (when the end-of-file is reached, e.g.)

Use **Next**, **Prev**, **Next 10**, **Prev 10** buttons on the left-hand panel of the main window to get the needed event from file (these functions are duplicated as items of the **Tools** menu, moreover, there is an **All** item in it which allows one to collect events from a data file). One can use event selection feature tuning it by clicking the **Filter** item in the **Options** menu to skip events that do not satisfy the choosen settings. Event selection dialog is shown on fig. 6.

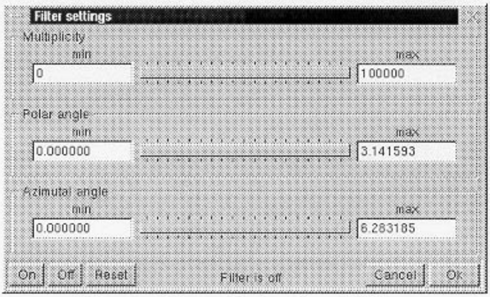

Fig. 6: Event Selection Dialog

One can choose the raw event representation by clicking **Picture** button on the main window left-hand panel and the wavelet spectrum representation — by clicking **Picture** button on the right-hand one. Instead of clicking **Picture** buttons one can choose corresponding items in the **Options** menu. Corresponding panels are shown on figs. 7 and 8.

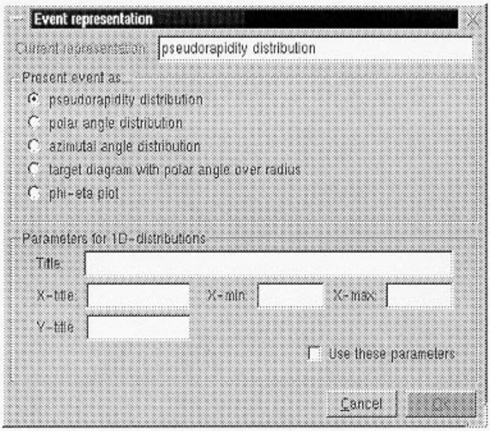

Fig. 7: Event Representation Dialog

The default event representation is pseudorapidity distribution. The range of histogram is calculated automaticaly over each event. It can be fixed by hand using the panel shown on fig. 7 instead, moreover, a histogram title, x-axis and y-axis labels can be choosen (fig. 4 shows defaults).

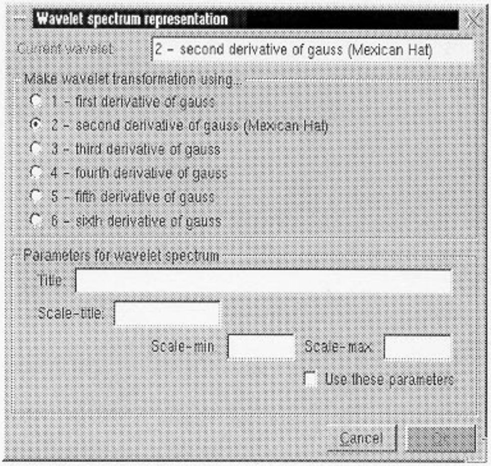

Fig. 8: Wavelet Spectrum Representation Dialog

The default wavelet used for transformation is the second derivative of the gauss function ("Mexican Hat"). The x-range and the x-axis label are the same as for the raw event histogram. The default scale-range is from 0 to 1/3 x-range. It can be fixed manually using the panel shown on fig. 8 instead, moreover, a wavelet spectrum title and scale-axis labels can be choosen (fig. 4 shows defaults).

Both **Save** buttons are used for saving corresponding images to EPS-files: file "en_r.eps" for raw event image and file "wsn_r.eps" for wavelet spectrum, where `n` is an event number in data file, `r` is an event representation number according to the panel on fig. 7.

The **Dump** button is used to save a wavelet spectrum matrix to the ASCII file (the x-axis grid is written first, then the y-axis one (scales), and finaly corresponding wavelet coefficients, line-by-line, from the minimum of scale to the maximum). The file "wcmn_r.dat" is created when the **Dump** button is pushed (`n` and `r` have the same meaning as above).

The **Slice** button allows one to view (see fig. 9) the wavelet transform at a choosen scale parameter (the last one is set by a slider and controled by a text entry in percent of the wavelet spectrum scale-range).

The **Wavelet** button allows one to draw wavelet spectrum with a better resolution or just redraw it (after **Slice** button is pushed, e.g.)

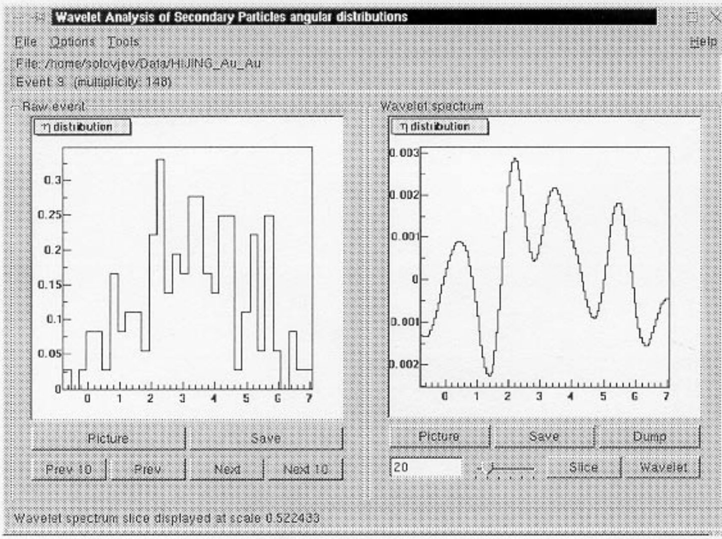

Fig. 9: Slice Feature

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WASP — программа вейвлет-анализа угловых распределений вторичных частиц. Версия 1.0. Руководство для пользователя

WASP — программа на C++, предназначенная для анализа угловых распределений вторичных частиц, образующихся в ядерных взаимодействиях. (WASP разработана для анализа данных экспериментов STAR и ALICE). Для этой цели используется вейвлет-анализ, причем для преобразований применяются гауссовы вейвлеты.

Программа WASP предоставляет удобный графический интерфейс (GUI), что делает ее простой для использования.

В настоящем руководстве представлены дизайн, краткое описание используемого алгоритма вейвлет-преобразований и GUI.

Работа выполнена в Лаборатории информационных технологий ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна, 2001

Soloviev A.G. E10-2001-105
WASP (Wavelet Analysis of Secondary Particles Angular Distributions) Package. Version 1.0. User's Guide

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