ADVACAM
Imaging the Unseen

TraX Engine GUI

Online version: https://wiki.advacam.cz/wiki/TraX_Engine_GUI

Contents

Introduction

This document is the user manual for the Data Processing Engine (DPE) Graphical User Interface (GUI). It includes sections on installation, steps for running the program, configuration of data processing and graphical visualization. Additionally, it provides detailed information on the structure of output folders and data products.

This manual is complemented by the webpage: https://wiki.advacam.cz/index.php/DPE, which contains updated information on the DPE platform.

Install and Run

Prerequisites

To utilize the full capabilities of the Data Processing Engine, the following software components are required:

- Python 3.10
- Python Packages:
  - matplotlib (version >= 3.4)
  - numpy
- RAM usage minimal 400 MB (example data consumes app 650 MB)
- Hard drive space usage is from 100 MB, but can be up to several GB (data from processing are stored on the hard drive)

Installation Instructions:

- Download the Program: Obtain the program archive/zip file from the official source.
- Extract Files: Navigate to the directory where you wish to install the program and extract all files from the downloaded archive/zip file.

Run DPE GUI instructions:

i. Windows: Click on the executable file to start the DPE GUI program:

trax_enegine.exe

ii. Linux:

- Open a Terminal.
- Navigate to the installation directory of the DPE.
- Execute the DPE with the following command: ./trax_engine.sh

Overview of DPE GUI (TraX Engine) Interface

The image illustrates a comprehensive overview of the DPE TraX Engine graphical user interface (GUI), which is divided into three main sections. This layout facilitates a broad range of tasks from data input and processing to visualization and analysis.

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Figure 1. Overview of DPE GUI (TraX Engine) interface.

Top menu bar

Contains menus such as 'View', 'Preferences', and 'Help', offering quick access to general settings, customization options, and assistance resources.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image3.png

Figure 2. Top menu bar.

Data Visualization Panels

Graph 1, Graph 2, and Graph 3: These panels display various data visualizations important for detailed analysis. Each graph comes with its toolbar allowing operations like exporting data, adjusting the display to logarithmic scale, and other customization features such as setting data binning.

Overview of Figure Options Dialog Box

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Figure 3. Overview of Figure Options Dialog Box.

Axes/Image Identifier: The dropdown menu allows users to select different components or layers of the figure to configure. Each component can be labeled or identified uniquely to facilitate specific adjustments.

Label Field: Users can enter a descriptive label for the selected component, enhancing the clarity of graphs or images. This label often appears within the graph itself or in legends and helps to identify different data sets or image layers.

Color Palette Selection: A dropdown menu offering various color maps such as 'RdYlBu' (Red-Yellow-Blue). This setting is important for visual data representation, as different color schemes can indicate intensity, density, or categories within the data.

Min Value: Defines the lower bound for the data values associated with the colormap. This can help in normalizing data presentation, ensuring that the colormap accurately reflects variations in the underlying data.

Max Value: Sets the upper boundary for the data values, which works in conjunction with the minimum value to scale the color mapping effectively.

OK: Saves the changes and exits the dialog box.

Cancel: Closes the dialog box without saving any changes.

Apply: Applies the changes without closing the dialog box, allowing users to immediately see the effect of their adjustments on the figure.

settings for data processing

General Settings

The *General Settings* section of the DPE GUI is central to configuring the data processing environment. This section is divided into several components, each with specific functionalities to enhance user interaction and data management efficiency.

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Figure 4. Overview of the General Settings section of the DPE GUI with detailed description on the right side.

Input Data and Calibration Matrices

- Input Data: Users can insert the path to the data file which will be processed. Clicking the 'Open' button allows for browsing and selecting the appropriate file. Data collected in either data driven or frame mode can be processed (t3pa/clog formats).

- Calibration Matrices: Similar to the data file, the path for calibration coefficients matrices can be entered here. Calibration files are crucial for converting measure time over threshold (ToT) values to energy and can also be loaded via 'Open' button.

Simple Settings

- Sampling Time: Set the interval in seconds for sampling the data.
- Particle Identification Algorithm: Choose from a dropdown menu to select the algorithm suitable for particle identification based on the data and experimental conditions. Options for PID based on artificial intelligence (AI) Neural Networks (NN): 251, 252, 201, or 202. Access the Wiki page for further information.
- Sensor Bias: Sensor Bias in Volts.

Example: SensBias = 100 to specify that applied was 100 V. Default: 200.

- Sensor Thickness: Sensor thickness in micrometers.

Example: SensThick = 500 to specify the thickness of the detector as 500 micrometers. Default: 500.

- Chip Type: Select from the list: TPX (Timepix1), TPX2 (Timepix2), TPX3 (Timepix3) or Timepix4 (TPX)
- Sensor material: Select from the list: Silicon, Cadmium telluride, gallium arsenide or silicon carbide.

- Cluster Count: Specify the number of clusters to be processed per run, allowing users to manage the data volume per processing cycle.

Advanced settings

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image6.png

Figure 5. Overview of the Advanced Settings section of the DPE GUI.

- Sensor Width: Enter the number of pixels that represent the width of the sensor.
- Sensor Height: Similar to sensor width, this setting allows the user to specify the height of the sensor in pixels.

- Mask File Name: This field should contain the filename of the mask file used during data processing. Masks are typically used to exclude certain areas of the sensor from analysis. Save mask as `Mask.ini`

Example of Mask

- [0-255,0-205] [0-5, 0-255] [254-255, 0-255] [0-255,0-5] [0-255,254-255]
- Mask File Path: Here, users should specify the full directory path where the mask file is located, ensuring the software can correctly access and apply the mask.

- Direction Track Condition: When checked, this option enables the tracking of directional data.
- Radiology Units: Toggling this changes the units used in data processing and display from micrograys per hour (μGy/h) to grays per second (Gy/s).
- Ignore Clusters at Sensor Edge: Activating this setting will ignore any data clusters detected at the edges of the sensor,

often necessary to avoid edge distortions in the analysis.

- Timepix High Energy Correction: This checkbox enables specific corrections for high-energy particles detected by Timepix sensors, improving accuracy in high-energy experiments.

- Cluster Length Correction: A dropdown menu allows selection of the method used to correct the length calculation of clusters during processing, important for accurate LET measurements. In DPE GUI, there are two methods available for calculating length with the default method being Method 1. To select a different method for length derivation used in the formula for LET calculation, choose from the following list:

1: Based on weighted standard deviation subtraction from projected length (Default formula).

2: Based on projected width subtraction from projected length.

- Dead Time of Frame: Defines a period, in milliseconds, where data is not recorded between frames—useful in high-speed data capture to prevent data overlap.
- Acquisition Time of Frame: Specifies for how long each frame's data is acquired. It is expressed in seconds.
- Coincidence Time: Sets the time window, in milliseconds, for detecting coincidences between events, essential for time-correlated particle detection studies.

- OK: Clicking this will save all changes and close the window.
- Cancel: This button exits the window without saving changes, keeping previous settings.

Analysis Options

Provides checkboxes for toggling specific types of analysis such as Direction, Coincidence, Radiation Field Recognition, and Frame analysis. These settings allow for customized data processing based on the study requirements.

Input Parameters File

Facilitates loading a pre-configured parameters file that sets various processing parameters. Users can load the desired parameters file by navigating to it and then clicking the 'Load' button. The `ParametersFile.txt` contains essential information related to the configuration of the detector, data input/output, calibration files, and other parameters required for processing. The DPE GUI platform includes an example dataset with a predefined `ParametersFile.txt`.

Customization Steps:

1. Open `ParametersFile.txt` in a text editor.
2. Modify the following parameters to match your setup:

iii. FileInPath = [Path to your input data]

iv. CalMat = [Path to your calibration matrices]

v. FileOutPath = [Path for output data]

Example Configuration:

FileInPath = "C:\WORK \example\data\"

CalMat = "C:\WORK\example\cal_mat\"

FileOutPath = "C:\WORK\example\out\"

For further details on customizing the output, refer to the Wiki page: https://wiki.advacam.cz/index.php/DPE

Export Data

This function enables users to define a path to export processed data. After setting the path, clicking the 'Export' button will save the output accordingly.

Results

Displays the output from the last data processing session, including the count of particles processed, the total processing time, and the count of samples, providing quick access to processing outcomes.

Start Processing

The blue 'Start processing' button at the bottom is used to initiate the data processing. A progress bar alongside shows the completion rate, which fills up to 100% upon the end of the process.

Log Panel

This panel, see figure 6, is particularly valuable for system administrators or users needing to troubleshoot operations, verify processes, or ensure that all system activities are running as expected. In case of an error check the Log Panel.

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Figure 6. Overview of the Log Panel.

Filters

When dealing with a mixed field and the need to isolate specific types of particles independently of the existing particle recognition algorithms, one can define custom filters in the Filters.ini file or directly in the interactive Filter section, see image below. These filters allow for the specification of ranges for cluster parameters, which can then be applied to the data. For instance, within the same dataset, one might seek to isolate thermal neutron interactions and perpendicular protons. Below is an example demonstrating the implementation of advanced filters:

[Y]

Range = 205.0,255.0

[E]

Range = 260.0,2170.0

[Size]

Range = 3.0,62.0

[Height]

Range = 150.0,610.0

[BorderPixCount]

Range = 5.0,35.0

[Roundness]

Range = 0.55,1.0

[Linearity]

Range = 0.0,0.7

[WidthProj]

Range = 0.95,8.1

[StdAlong]

Range = 0.1,1.5

[StdPerp]

Range = 0.1,1.8

[Thin]

Range = 0.36,1.1

[Thick]

Range = 0.0,0.63

[CurlyThin]

Range = 0.3,1.0

[EpixMean]

Range = 8.0,290.0

[AngleElev]

Range = 4.5,42.0

[LET]

Range = 0.45,3.7

[Diameter]

Range = 2.4,9.0

This panel is essential for users who need to perform targeted analyses by filtering out irrelevant or specific data. It supports complex analytical tasks by providing robust control over which data points are included based on quantitative criteria.

Filter Panel Overview

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image8.png

Figure 7. Overview of the Filter panel.

Variable List: A table with rows for different variables such as AngleAzim, AngleElev, BorderPixCount, etc., where each variable can be individually set with minimum and maximum values. This allows users to define thresholds or ranges for the data they want to include or exclude in the analysis.

Min and Max Columns: These columns are used to enter the desired minimum and maximum values for each variable, effectively setting the bounds for data filtering. For instance, users can limit AngleAzim between 5.0 and 40.0, ensuring that only data within this range is processed or displayed.

Cluster Count: Specifies the number of clusters to display, which helps in managing the visual density and processing load when analyzing large datasets.

Apply Button: Commits the entered filter settings and applies them to the data.

Reset Button: Resets all filter settings to their default values, offering a quick way to start over the configuration process.

Switch to Filtered Out Particles: A toggle that, when activated, displays the particles or data points that have been filtered out based on the current settings. This is useful for verifying what is being excluded from the analysis.

Use in Next Processing: A checkbox that, if selected, ensures that the current filter settings are retained and used in the next data processing cycle.

Results: Shows the outcome of the current filtering, typically indicating the number of clusters or data points that passed or failed the filters.

Import Section: Allows users to load filter configurations from an external file, which is helpful for applying previously defined or standardized filter settings.

Export Section: Enables saving the current filter settings to a file for reuse or documentation purposes.

The import/export functionality further enhances workflow efficiency by facilitating the reuse of filter configurations across different sessions or projects.

After inserting the filters, one needs to apply it by clicking on the Apply button. Afterwards in the graphical visualization will be displayed the output from filters which passed the criteria. If user selects a certain number of clusters (see cluster count), then push Enter button outside cluster count box and apply again the filters by clicking on the Apply button.

Processing Panel

The Processing Panel is integral to managing data processing tasks within the application. It provides tools to handle multiple processes simultaneously, adjust process settings, initiate processing tasks, and view logs related to processing activities.

Processing Panel Overview

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image9.png

Figure 8. Processing Panel Overview.

Process Selection Dropdown: Allows users to select from existing processes or switch between them to view and adjust settings or monitor their progress.

Create New Process: Users can initiate a new processing task by defining its parameters and settings. This is essential for starting separate analysis tasks without interference from or to other ongoing processes.

Delete Process: This option permits the deletion of existing processes, useful for managing space or removing outdated process setups.

Open Log Button: Opens a log file or log panel that provides detailed feedback on the processing activities. This feature is crucial for troubleshooting and understanding the flow of data processing, especially to check for errors or confirm successful completions.

Start Processing Button: Begins the data processing task as configured. This button is typically used after all settings have been confirmed.

Progress Bar: Displays the current progress of the data processing task, giving users a visual indication of how much of the task has been completed and how much remains.

Data Visualization and Analysis Tools

General

The General panel serves as the primary interface for initial data visualization, containing three key graphs (see figure 9).

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Figure 9. Data visualization: General panel overview.

Particle Count with PID (Particle Identification) Graph (Top Left): This graph displays the particle count over time, with particle discrimination. The PID algorithm classifies particles into the following categories: total, protons, photons & electrons, ions, and others, each represented with distinct colors. Users can export the data, toggle the logarithmic display of the axes, and navigate through different time points to examine specific data intervals.

2D Visualization of Clusters E in the Sensor (Top Right): Presents a spatial map showing the distribution of energy clusters within the sensor.

Includes an interactive element where users can adjust the number of clusters displayed, enhancing the granularity of the visualization based on the user's needs.

Histogram of Deposited Energy (Bottom): A histogram of deposited energy in the sensor for all particles. Similar to the first graph, this includes options for exporting data, adjusting the logarithmic scale, and setting the bin size for detailed analysis. The user can select to visualize histograms of other cluster parameters/variables.

Histograms

The Histograms panel in the DPE GUI provides a multipurpose interface for the visualization and analysis of data distributions across a range of cluster parameters/variables. It allows users to quickly generate and customize histograms, which are essential tools for statistical data analysis. The panel features include controls for selecting the data variable, adjusting the binning, and toggling between logarithmic and linear scales to suit different requirements. In figure 10 can be seen the overview of the histogram panel. For illustration of other histograms of cluster parameters/variables, in figure 11a is displayed histogram of height and in figure 11b histogram of PID.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image11.png

Figure 10. Overview of histograms panel.

a) File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image12.png b) File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image13.png

Figure 11. Selected histograms from Data visualization section histograms. The following histograms are displayed: a) height (H), b) Particle identification (PID) class.

Clusters

The *Clusters* section of the DPE GUI focuses on providing detailed visualizations of data clusters, important for analyzing spatial and energy distributions within the dataset. This section includes two main types of visualizations along with interactive tools to enhance data interpretation.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image14.png

Figure 12. Overview of data visualization section Clusters.

Single-cluster Visualization: Displays a detailed view of a selected single cluster, showing energy levels across different sensor pixels. Each pixel displays energy in color scale, which allows for a quick assessment of the energy distribution within a cluster.

2D Visualization of Clusters E in the Sensor: Provides a comprehensive spatial view of energy distribution across the sensor area 256 by 256 pixels representing 14.08 by 14.08 mm^2. In this case, 300 cluster counts were displayed.

Time Evaluation

The *Time Evaluation* panel in the DPE GUI presents a set of graphical tools for monitoring and analyzing different types of particle fluxes and dose rates across specified time intervals.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image15.png

Figure 13. Overview of the Time evolution panel.

The following graphs are displayed in this panel:

Total Flux (Top Left): Displays the total particle flux measured over time in particles per square centimeter per second (particles/cm^2/s). Overall particle flux distribution over the measurement's duration can be seen.

Flux with PID (Top Right): Shows the particle flux over time, with particle identification where data are discriminated and sorted into: protons, photons & electrons, ions, and others. This allows comparison of flux between different types of particles.

Total Dose Rate (Bottom Left): Plots the total dose rate measured over time in grays per second (Gy/s).

Dose Rate with PID (Bottom Right): Similar to the flux graph, this graph shows the dose rate with PID providing a detailed look at how different particles contribute to the overall dose rate. This type of data processing could be useful for understanding which particles are the primary contributors to radiation dose during the measurement and managing radiation safety.

a)File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image16.png b)File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image17.png

Figure 14. Selected data from Time evaluation section of data visualization with PID of dose rate for algorithm 251 and for algorithm 252.

Figure 14 shows an example of particle flux with PID algorithm specific for the detector used: in a) 251 with 3 classes and b) 252 with 6 classes. In case of other algorithms used, the specific particle classes will be recognized and displayed.

PID (Particle Identification)

The *PID* (Particle Identification) section in the DPE GUI is important for analyzing particle characteristics and classifying them using artificial intelligence neural networks. This panel provides a multi-layered view of particle data, integrating histograms, time series, and spatial distribution maps to offer a comprehensive analysis based on particle types. This section facilitates detailed investigations into the characteristics and behaviors of different particles detected in the dataset.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image18.png

Figure 15. Overview of data visualization section PID.

The key components of the PID panel are listed below:

Histograms of Energy: Displays energy distributions for various particles, with histograms colored for different particle types such as protons, photons & electrons, ions, and others. Users can select the cluster variable (Cluster parameter) from drop-down menus, adjust the number of bins, and switch between logarithmic and linear scales to adjust the visualization to specific analytical needs.

Time Graphs: Plots the count of different particle types over time. Includes options to select physics products correlated with PID data, such as count of particles, flux, fluence, dose rate, and deposited energy, enhancing the graph's utility for various studies.

Spatial Distribution Maps (Bottom): Four separate maps show the spatial distribution of total particles, protons, photons & electrons, and ions. The first map shows the integrated number of particles set in the cluster count. The following maps are corelated to the total map of integrated particles and show the detected number of particles for each class/type. Tools are available for exporting data, adjusting the number of clusters displayed, and navigating through the dataset, enabling users to explore spatial patterns and correlations.

Filter

The *Filter* section in the DPE GUI is designed to show how data, which has passed/or not (in case the switch button was used) through applied filters, is visualized.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image19.png

Figure 16. Overview of data visualization in section Filters for data which passed the applied filters.

The following graphs are displayed in Filter panel:

1D Histogram of Selected Variable: Presents a histogram plotting the distribution of a selected variable, in this case energy (E), across the dataset that meets the filter criteria. Users can adjust the number of bins, choose the variable from a dropdown menu, and switch between logarithmic and linear scales to customize the view according to their analytical preferences.

2D Histogram of Selected Variables: A two-dimensional histogram that cross-tabulates two selected variables, such as energy and size in this case, displaying counts of occurrences in a color-scale. Allows users to select variables for the x and y axes, adjust the bin sizes, and toggle the logarithmic display to enhance the visualization of data correlations and distributions.

Single-cluster Visualization: Provides a detailed visual representation of a single cluster's data, showing energy distribution across sensor pixels.

2D Map of Clusters Energy: Displays a spatial map showing the distribution of energy across clusters within the dataset which passed the filters. Users can adjust the number of clusters displayed, facilitating customized view.

Direction

The *Direction* panel of the DPE GUI focuses on analyzing the directional properties of particle trajectories, specifically through azimuth and elevation angles. This analysis is important for understanding particle orientation and behavior within the studied environment.

The primary objective of this analysis is to acquire information regarding particle directions. To achieve this, an analysis of each detected track via clustering process is performed. Then, a directional analysis is performed for the elevation and azimuth angles, accomplished by means of particle track length estimation. Four main features are analyzed:

- Particle length in sensor plane or L_{2D} – Estimation of the particle track length in the sensor plane. If a high-energy (HE) particle traversed fully through the sensor, this length should be equal to the length of a projection of the line going from the entry point to the exit point.
- Particle length in sensor volume or L_{3D} – Estimation of the particle track length in the sensor volume. If an HE particle traversed fully through the sensor, this length should be equal to the length of a line going from the entry point to the exit point.
- Azimuth angle – The angle between the y-axis and the cluster axis.
- Elevation angle – the angle between the z-axis and the estimation of the particle trajectory in the sensor volume.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image20.png

Figure 17. Data visualization of section Direction. (top) histogram of Azimuth angle, (bottom) histogram of elevation angle and (right) Polar plot of distribution of azimuth and elevation angle.

Histogram of Azimuth Angle: This histogram displays the distribution of azimuth angles of particle tracks, plotted on a logarithmic scale to handle a wide range of data. Peaks in the histogram indicate preferred particle directions or orientations. Users can export the data for further analysis and adjust the binning of the histogram to fine-tune the resolution of angular distribution details.

Histogram of Elevation Angle: Similar to the azimuth histogram, this graph shows the distribution of elevation angles, showing particle distribution relative to the horizontal plane.

Polar Plot of Distribution of Azimuth and Elevation Angles: Combines both azimuth and elevation data into a single polar plot, providing a comprehensive 2D representation of particle directions. Number of particles are displayed in color logarithmic scale. This visualization is useful for identifying dominant particle trajectories.

Frame

Provide options to view or analyze individual frames in case of data collected in frame mode.

Coincidence

The *Coincidence* section of the DPE GUI is crucial for analyzing events where multiple particle detections occur at nearly the same time (within 100 ns in this case).

The objective of this analysis is to provide users with statistical information about coincidence groups in terms of basic physical products. Visualization of coincidence groups is also included. Examples of statistical information are presented. Figure below illustrates how particle counts change over time within the coincidence groups.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image21.png Figure 18. Data visualization of section Coincidence. 1D histogram of mean count of particles in event, histogram of coincidence group count, histogram of Time difference, clusters in coincidence.

The following visualizations graphs regarding particle coincidences can be seen in the Coincidence panel from above:

1D Histogram of Mean Count of Particles: This graph shows the mean count of particles per event over time. Allows users to observe fluctuations and trends in the average number of particles detected per event, indicating variations in particle generation or detection efficiency.

1D Histogram of Coincidence Group Count: Displays the total count of coincidence groups (events where multiple particles are detected simultaneously) over time.

1D Histogram of Time Difference of Particles in Coincidence: Plots the distribution of time differences between detected particles within coincidence groups.

Clusters in Coincidence: Shows cluster groups which are seen as a group of particles in coincidence, see more examples in figure 19.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image22.png

Figure 19. Overview of data visualization in section coincidence showing 2 groups of particles in coincidence.

Spatial Maps

The *Spatial Maps* panel in the DPE GUI provides an intricate view of spatial distributions related to particle clusters. These maps are important for analyzing the spatial characteristics of particle events and their distribution across a given sensor area. Various spatial maps can be seen in figure 20 including: 2D map of cluster counts, cluster energy, height and size. These type of analyzes can be used also for imaging, radiographies.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image23.png

Figure 20. Overview of data visualization in the section spatial maps.

RFR (Radiation Field Recognition)

Provides information on radiation field recognition, see output file for more details and analysis.

Exported results and output

After exporting the output to the designated path, the following folders will be listed:

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image24.png

Figure 21. Output folder.

CoincEvent (coincidences)

This folder contains information on the coincidence of events in numerical forms. The files can be used to plot histograms or visualized events in coincidences.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image25.png

Figure 22. Overlay of folder coincidences containing files of related histograms, plots and a list of coincidence events.

Direction

The output overlay of the folder Direction can be seen below. It contains input files that can be used to plot various types of histograms both 1D and 2D of elevation and azimuth angles. In addition, the file `DirectionList.json` can be used to plot multiple parameters related to other directional quantities: e.g. length 2D and 3D.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image26.png

Figure 23. Overlay of folder direction containing files of related histograms and a list of of coincidence events.

EventVisual (Event Visualization)

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image27.png

Figure 24. Overlay of folder event visualization containing files of 2D Maps of deposited energy for all particles (integrated) and particle plots of (Total) and with particle discrimination and classification. Plots of individual clusters can be found here.

File (ASCII output)

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image28.png

Figure 25. Overlay of folder File.

This folder contains information related to different formats of the data. For example, in file `ClusterLog.clog` the data from data driven-mode (pixels, Toa + ToT mode) is divided into frames of 100 ns acquisition time.

The clusterization stage is succeeded by cluster analysis, which evaluates both the morphological and spectral features of the clusters. File `EventList.advelist` and `EventListExt.advelist` contain a list of cluster parameters for each cluster. A detailed list of all cluster parameters is given in Table 1.

Table 1. List of cluster parameters processed for each particle and their description.

Parameter name	Unit	Description
EventID	-	ID of events. It has the same value if particles are in coincidence.
X	px	X coordinate of cluster.
Y	px	Y coordinate of cluster.
E	keV	Energy of cluster. It is sum of energies of all cluster pixels.
T	ns	Time. It is the minimal time of cluster pixels.
Flags	-	Frame number for data collected in frame mode.
Size	px	Count of cluster pixels.
Height	keV	Maximal value of energy of cluster pixels.
BorderPixCount	px	Count of border pixels in cluster.
Roundness	-	Morphological feature, the similarity of cluster to circle.
AngleAzim	deg	Estimation of cluster direction as an angle in sensor plane.
Linearity	-	Morphological feature, similarity of cluster to a line.
LengthProj	px	Length of cluster. The maximal distance between pixels, L2D.
WidthProj	px	Maximal distance between pixels perp. to the cluster axis.
IsSensEdge	-	Information whether cluster is at sensor edge, 1= True.
StdAlong	px	Standard deviation of pixels with respect to cluster axis.
StdPerp	px	Standard deviation of pixels perpendicular to the cluster axis.
Thin	-	Morphological feature expressing thinness of cluster.
Thick	-	Morphological feature expressing thickness of cluster.
CurlyThin	-	Combination of cluster thinness and inverse of linearity.
EpixMean	keV	Mean value of pixels energy in cluster.
EpixStd	keV	Standard deviation of pixels energy in cluster.

Length3DCorrStd	um	L3D, particle trajectory corrected for based on weighted STD.
AngleElev	deg	Elevation angle of cluster.
LET	keV/um	Linear energy transfer based on the corrected length and energy (E).
Diameter	px	Diameter of a cluster.
PIDClass	-	Shows the class into which the cluster was classified.

Furthermore, physics products and data evaluation output is summarized in `SamplingList` which is available in two output formats: `json` and `ASCII/txt`.

Table 2. Description of physics products in `SamplingList`.

Name	Unit	Description
TimeLive_Sum	s	Sum of the time when detector was recording data excluding dead time
TimeSampling	s	Sampling time
CountSample	-	Number of counts in a sampling time
Time_First	ns	Time of arrival of the first hit cluster
Time_Last	ns	Time of arrival of the last hit cluster
Time_Last	s	Time of arrival of the last hit cluster
CountPixHit_Sum	-	Sum of pixels hit in the given data set
CountPixHit_Sum_Proc	-	
CountParticle_Sum	-	Sum of clusters in the given data set
CountParticle_Sum_Proc	-	
CountRate_Mean	s^{-1}	Average of clusters in the given data set per second
CountRatePixHit_Mean	s^{-1}	Average of pixel hits in the given data set per second
Fluence_Sum	cm^{-2}	Sum of fluence of particles in the measured data set
Flux_Sum	Particles/cm^{-2}/s	Sum flux of particles
EnergyDep_Sum	keV	Sum deposited energy in the given data set
Dose_Sum	uGy	Sum absorbed dose in the given data set
DoseRate_Mean	uGy	Average dose rate in the given data set
ClassNames	-	1) Protons 2) Photons and electrons 3) Ions 4) Others
AlgorithmSwitch	-	251
CountParticle_Sum_Class	-	Total number of particles for each identified class of particles in the given data set
CountParticle_Sum_Class	%	The personage of total number of particles for each identified class in the given data set
CountRate_Mean_Class	s^{-1}	Mean count rate for each identified class in the given data set
Fluence_Sum_Class	cm^{-2}	Sum of fluence for each class of particles identified in the measured data set
Flux_Sum_Class	Particles/cm^{-2}/s	Sum of flux for each class of particles identified in the measured data set
EnergyDep_Sum_Class	keV	Sum of deposited energy for each class of particles identified in the measured data set

Dose_Sum_Class	uGy	Sum of absorbed dose for each class of particles identified in the measured data set
DoseRate_Mean_Class	uGy/h	Mean dose rate for each class of particles identified in the measured data set

All the information in the `SamplingList` is given for each sampling interval that was set in the `ParametersFile.txt`.

SigVec (Significant Vectors)

This folder contains information on Significant vectors analysis structured into 2 files. The file below contains information on vector parameters used to for evaluation and their intervals. For example, Cluster parameter Size contains 3 intervals: [-1, 5]; [5,20] and [20, 1e+200] and the corresponding significant vectors are given in the next file `SigVec.vec` in the first 3 lines. Data are normalized to 1 as indicated in the info file. If user wants to define other cluster parameters for significant vectors, then he should define the variable title and the intervals. Data can be normalized to 1 or weighting can be applied.

a) File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image29.png

b)File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image30.png

Figure 26. *Example of a) significant vectors information file and b) of significant vectors output file.*

Hist (Histograms)

This folder contains histograms of cluster variables from Table 1. These histograms are generated using data from `EventListExt.advelist` with a defined binning interval. Histograms are produced in both logarithmic and linear scale. Individual histograms in ASCII formats are available in this folder, along with details about the binning of each histogram and its intervals.

An example of Histogram information can be found below: File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image31.png

Figure 27. Example of histogram information.

The binning of the histograms can be adjusted using the `ParametersFile.txt` if the user desires different intervals or binning values or directly in the interactive Histogram Panel.

In this file are detailed the mean value of the histogram, its error as seen below:

- Mean: 950.533
- Mean Error: 21.874
- Standard Deviation: 1531.520
- Standard Deviation Error: 42.188

1D Histograms in graphical visualization are categorized by classes of particles and include the following Cluster parameters: deposited energy, height, and size. Additionally, histograms of all cluster parameters are available in ASCII format, sorted by classes of particles.

2D histograms in graphical visualization for total deposited energy of low energy clusters (0-1000 keV) and high energy clusters (from 0 to over 15 000 keV) can be seen in this folder. In ASCII format the histogram of cluster energy and size are processed by classes of particles

SpatialMap (Spatial graphs)

Spatial maps can be used for imaging of the beam or of objects. 2D visualization of various parameters can be found in this folder including: Sensor map of cluster position, map of cluster sum of deposited energy, map of cluster mean energy per pixel, cluster height, Cluster LET, and cluster size.

File:Vertopal 4d20fd67a374491d9eb38b2e430e2fc2/media/image32.png

Figure 28. Folder Spatial Maps containing 2D histograms of various parameters for all particles and with particle discrimination (PID).

Support and ISSUES

For technical support contact: Lukas Marek: Lukas.marek@advacam.cz

Issues and Help

Issues can be reported on github forum for issues:

https://github.com/lmareksla/trax_engine_gui_issues

Alternatively, you can send issues directly to the following email addresses:

- Lukas.Marek@advacam.cz
- Cristina.Oancea@advacam.cz
- Carlos.Granja@advacam.cz

Frequently asked questions

Q1: What is the difference between TraX Engine and DPE?

A: There is no difference. DPE was renamed into TraX Engine.

Q2: Is there any citation for using TraX Engine and DPE?

A: L Marek, C Granja, J Jakubek, J Ingerle, D Turecek, M Vuolo, C Oancea. Data Processing Engine (DPE): data analysis tool for particle tracking and mixed radiation field characterization with pixel detectors Timepix,2024 JINST 19 C04026

Q3: What type of data can be processed?

A: Various types of data formats can be used including both data driven and frame with extensions t3pa, clog, txt, etc. See more details on the wiki page: https://wiki.advacam.cz/wiki/DPE

Q4: How do I check if the calibration was applied correctly?

A: You can verify if the calibration was applied correctly by examining the output file "EventListExt.advelist" located in the output/File directory. Check the column labeled "Energy [E]".

- If calibration was applied correctly, the energy values for each cluster will be written with decimals (e.g., 3343.12).
- If calibration was not applied, the Time-over-Threshold (ToT) values will be written as integer numbers.

Q5: How do I find the calibration coefficients of my detector, or detector used for measurement?

A: The calibration coefficients (a, b, c, and t) are stored as ASCII files, each specific to an individual detector. You can access these coefficients using the PIXET software by following these steps:

1. Open the PIXET software.
2. Navigate to the settings section.
3. Select the chip settings.
4. Choose the option to extract coefficients.
5. Save the coefficients as ASCII files.

List of Acronyms

DPE –Data Processing Engine

CL – Command Line

WP – Web Portal

TPX – Timepix

TPX3 – Timepix3

LE – Low Energy

ME – Medium Energy

HE – High Energy

OD – Omnidirectional

PID – Particle identification

Si – Silicon