Positron Annihilation Lifetime Spectrum Analysis Application

PAS-Analyzer

Instruction manual

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1. Notes & Disclaimers

Thank you for choosing PAS-Analyzer (hereinafter referred to as ″this app″), a positron annihilation lifetime spectrum analysis application developed by TechnoAP Co., Ltd. Before using this app, please read these ″Notes & Disclaimers,″ be sure to follow their contents, and use it correctly.

Our company assumes no responsibility for any damages, including secondary damages resulting from the use of this app.



Prohibited Items

- It cannot be used for applications requiring special quality or reliability related to human life or accidents.



Notes

- Product specifications and related documents may change without prior notice.

2. Overview

PAS-Analyzer (hereafter referred to as this app) is a Python/Tkinter-based GUI analysis software developed for analyzing Positron Annihilation Lifetime Spectroscopy (PALS). This app improves the reproducibility and operability of data processing in laboratories and experimental settings.

Modeling and fitting of lifetime spectra

The measured lifetime spectrum is modeled as a convolution + 'constant background' of the ″sum of multiple exponential decay functions″ and ″device time resolution by Gaussian functions,″ fitted using weighted nonlinear least squares. For the meaning of formulas and parameters, please refer to the chapter on ″Principles of Analysis.″

Supports two main analysis modes

- ResolutionFit Mode:
  From measurement data of known samples (such as annealed iron), the device-specific time resolution function (FWHM) and sample lifetime are simultaneously fitted and determined.
- PositronFit Mode:
  By fixing the determined Time Resolution Function (FWHM), we precisely calculate the complex lifetime components (life and relative intensity) of unknown samples.

Analysis configuration management using JSON format

Analysis conditions (ROI range, initial values, free/fixed parameters etc.) can be saved and reloaded as JSON files, ensuring complete repeatability of analysis.

Practical text reports and multifunctional graphs

It outputs detailed text reports and allows you to visually check attenuation curves, fitting curves, individual attenuation for each lifetime component, and normalized residual plots in real time.

This document describes the handling of this app. The contents of this document may be changed without notice.

3. Revision History

October 2026　Version 1.0.0　first edition

4. Installation

This app runs on Windows. You can install this app in an interactive format using the installer provided on the included CD. The installation steps are as follows.

（1） Log in to your PC with administrator privileges.
（2） Run ″Setup.exe″ located in the ″Installer_PAS-Analyzer″ folder on the included CD-ROM. Proceed with the installation following the interactive prompts. The default installation destination is as follows.
C:¥Program Files¥TechnoAP¥PAS-Analyzer
（3） After installation is complete, a shortcut icon will appear on your desktop.

To uninstall, select ″PAS-Analyzer″ from ″Add and Remove Programs″ to remove it.

5. Basic Analysis Flow

Standard lifetime spectrum analysis using this app proceeds in the following seven steps.

[1. Data Load] ➔ [2. Spectrum Settings] ➔ [3. Resolution Settings] ➔ [4. Background Settings] ➔ [5. Lifetimes Settings] ➔ [6. Run Fit] ➔ [7. Check and Save Report/Graphics

(1) Load spectral data: Open the CSV file or .dat file.
(2) Spectrum Settings : Check and adjust the initial values for the analysis area, area calculation area, time scale, and time zero.
(3) Resolution Settings: Select the analysis mode (ResolutionFit / PositronFit) and set the width (FWHM) and shift (Shift) of the Gaussian resolution function.
(4) Background Settings: Select the method for calculating the constant background (Free / Fixed channel average / Fixed value).
(5) Lifetimes Settings: Specify the number of lifetime components to analyze, and set the initial lifetime, intensity, and source correction flags for each component.
(6) Fitting Execution: Perform least squares fitting using the ″Fit″ → ″Run fit″ menu or the keyboard shortcut key F5.
(7) Checking and saving results: Check the physical quantities and statistical indicators calculated in the Analysis tab, visually evaluate fit in the Graphics area, and then output configuration JSON, reports, and images.

6. Principles of Analysis

In this chapter, we'll explain what the app fits into and how to read the results.

6. 1. What is being measured

Positrons annihilate in a substance and emit γ rays. The time from when a positron enters the sample until it annihilates is called positron lifetime. Positrons tend to be trapped in electron-scarce areas such as atomic voids and pores, where their lifetime is extended. Therefore, the value of the lifetime allows us to estimate the size of the cavities and voids, and the intensity of each lifetime gives an estimate of the quantity.

The Positron Annihilation Lifetime Measurement device measures the difference in detection times between the γ line (1.27 MeV for ^{22}Na) indicating positron generation and the γ line (511 keV) indicating annihilation multiple times, counting the number of counts for each time difference to obtain the lifetime spectrum. This app calculates lifetime and intensity from this spectrum.

6. 2. Formula for Fitting

The measured lifetime spectrum shows that the exponential attenuation of each lifetime component is slightly blurred by the device's time resolution (Gaussian function), with a certain background added. This app fits the following models to the spectrum using weighted nonlinear least squares methods.

$$N(t) = B + \sum_{i=1}^{n} \left[\frac{I_i}{\tau_i} e^{-t/\tau_i} \right] \otimes R(t - t_0)$$

$$R(t) = \sum_{p} \omega_p \cdot \mathrm{Gauss}\left(t; \mathrm{FWHM}_p, \mathrm{Shift}_p\right)$$

$$\mathrm{FWHM} = 2\sqrt{2\ln 2}\,\sigma \approx 2.355\sigma$$

$$I\%_i = 100 \times \frac{I_i}{\sum_j I_j}$$

⊗ represents convolution. In actual calculations, the values integrated from each channel's time scale are used. The correspondence between the expression symbols and the items on the screen is as follows.

- τ_i [ns] : Lifetime. Tau in the Lifetimes tab
- I_i : Intensity (area,. counts). I (area) in the Lifetimes tab
- $I\%_i$: Relative intensity (area ratio. Total 100%). Lifetimes tab fit I%
- $R(t)$: Instrument response function (time resolution function). The sum of multiple Gaussian functions
- FWHM_p [ns] : Full width at half maximum (FWHM) of the Gaussian function (time resolution).
- ω_p [%] : Relative intensity of the Gaussian function. Intensity in the Resolution tab
- Shift_p [ns] : Misalignment of the Gaussian function. Shift on the Resolution tab
- t_0 [ch] : Time origin (peak position). Time zero in the Spectrum tab
- B [counts/ch] : Constant background. Background tab

6. 3. ResolutionFit and PositronFit

Both have the same formula above. The only difference is whether you move or fix the FWHM of the device function by fitting.

- ResolutionFit : Operate the FWHM (G) and determine it simultaneously with its lifetime. Used when the device's resolution is unknown or when you want to obtain it after each analysis.
- PositronFit : Enter the pre-determined FWHM and fix it (F), then fit only the lifetime and intensity.

Generally, the spectrum of a known sample is analyzed with ResolutionFit to determine FWHM, and the value is input into PositronFit to analyze unknown samples. With only ResolutionFit, it is also possible to calculate both lifetime and FWHM simultaneously.

6. 4. G and F, Source Correction

- G (Guess) : Adjust the value by fitting. The input value is the initial value.
- F (Fixed) : Fix it to the value you entered.

G/F can be selected by lifetime, intensity, FWHM, shift, time origin, and background. However, the intensity (%) of the first Gaussian function is automatically determined by subtracting the sum of the second and subsequent Gaussians from 100%.

When measuring with a ^{22}Na source sandwiched between samples, components that have annihilated in the source or encapsulant will also be mixed into the spectrum. If these lifetimes are known, check the source option in the Lifetimes tab and treat the lifetime of those components as fixed (F). If necessary, you can also fix the intensity with fixed intensities (%).

6. 5. Calculation Methods

Fitting is performed using weighted nonlinear least squares methods. Lifetime, intensity, resolution, time origin, and background values are determined iteratively so that χ^2 is minimized. Weights are determined from the count of each channel.

For calculations, the least squares method (trust-region method) from a general-purpose numerical computation library is used, and the parameters are set within physically reasonable ranges. The standard deviation (±) is a guideline value obtained from a linear approximation at the converging point.

Because of iterative calculations, results may vary depending on the initial value. To check whether convergence has occurred, please refer to the residual graph and Reduced chi-square (see "Troubleshooting").

6. 6. How to read the results

- Lifetime & Intensity: tau (lifetime) and I% (relative intensity) are the main results. ″±″ is the standard deviation (Std deviations), which only applies to values calculated in G.
- Chi-square : $\chi^2 = \sum_k \left(\frac{y_k - f_k}{s_k}\right)^2$ y_k is the measured data, f_k is the model value, and s_k is the standard deviation (weight) determined from the statistical fluctuation (Poisson statistics) of the counts in each channel.
- Degrees of Freedom: Number of analysis channels - Number of parameters moved during fitting.
- Reduced chi-square : χ^2 ÷ degrees of freedom. The closer to 1, the better the model matches the data. If the value exceeds 1 significantly, review the number of components, analysis range (Fit min / max), initial values, and background.
- Residual: (Data - Model) divided by standard deviation. If the values are evenly varied around 0, they are accurate. If there are waves or biases, the model or analysis conditions may not be appropriate.

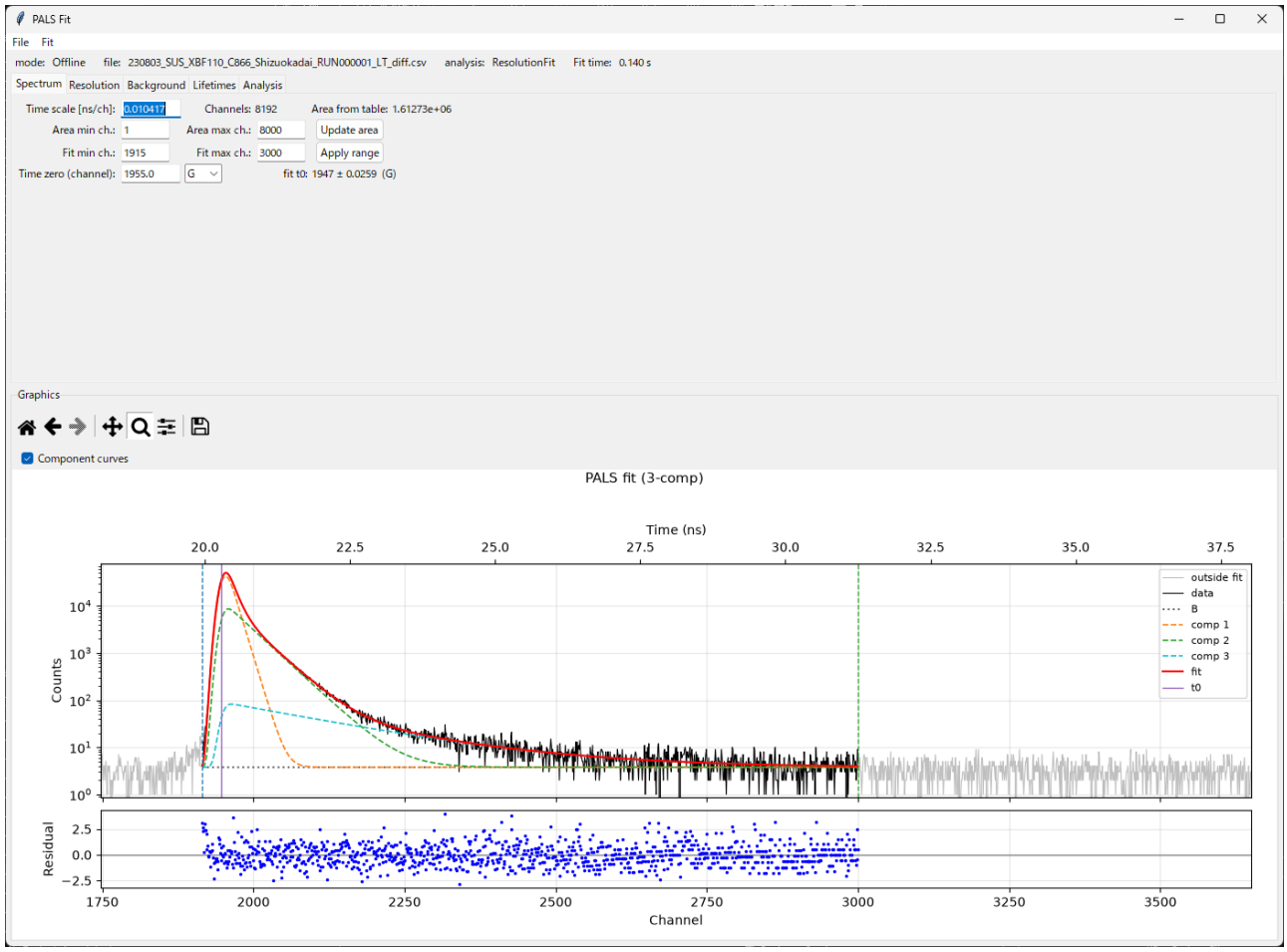
Increasing the lifetime component reduces χ^2, but the standard deviation increases, causing components that are physically meaningless to appear. Please analyze with the minimum necessary number of components.

7. Screen

7. 1. Layout

The PAS-Analyzer screen is designed as follows to enable intuitive operation.

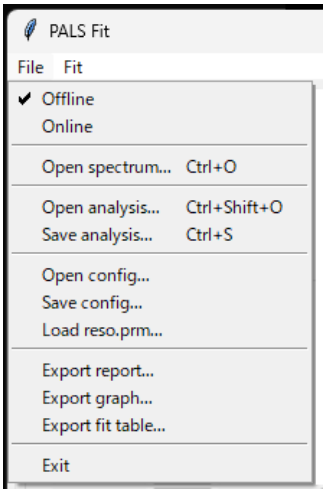
- Top of the screen (header area): Displays the window title, currently open spectrum file name, and status such as analysis execution.
- Central section (Main tab area): Five tabs for setup and verification (Spectrum, Resolution, Background, Lifetimes, Analysis) are arranged.
- Bottom of the screen (Graphics area): Displays spectra, fitting curves, curves for each lifetime component, and residual graphs.



7. 2. Menu

From the menu bar at the top of the screen, you can access detailed menu functions related to file input/output and analysis execution.

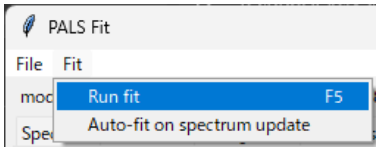
File menu



・Online / Offline switching:
- ➢ Online Mode: The specified spectrum file is automatically reloaded every 2 seconds, supporting real-time data updates (automatic initial estimation of t0 is only performed on the first load).
  To link with the Positron Annihilation System application for TechnoAP positron annihilation life measurement devices, you can specify the Lifetime_Spectrum.csv that updates every 1 second during measurement in the application installation folder (default is C:¥TechnoAP¥PositronAnnihilationSystem) using the Open spectrum described later.
- ➢ Offline Mode: Static storage of the loaded file for analysis (normal operation).

・Open spectrum... : Open the measurement data (CSV or .dat). For file formats, please refer to Section 7.10.1, ″Spectral file″.
・Open analysis.. : Open the analysis result file (*_analysis.csv saved in Save analysis).
・Save analysis.. : Save the analysis results with any file name. Save the fitting results, spectrum, fit curve, and report into a single CSV file (open in Excel). The initial file name is ″Spectral File Name_analysis.csv″.
・Open config.. : Load the analysis configuration file (JSON).
・Save config... : Save the current configuration conditions in JSON format.
・Load reso.prm... : Load reso.prm (resolution settings file).
・Export report... : Save the analysis report text displayed in the Analysis tab to a file.
・Export graph... : Save the graph currently displayed in the Graphics area as a high-resolution image.
・Export fit table... : Outputs a CSV that organizes the main parameters and standard deviations of the fitting results.
・Exit : Close the application (the default state at exit will be automatically saved for the next startup).

Fit Menu



・Run fit (F5) : Perform a lifetime fitting calculation.
・Auto-fit on spectrum update : Enables or disables automatic fitting whenever new spectrum data is detected in Online mode..

7. 3. Status

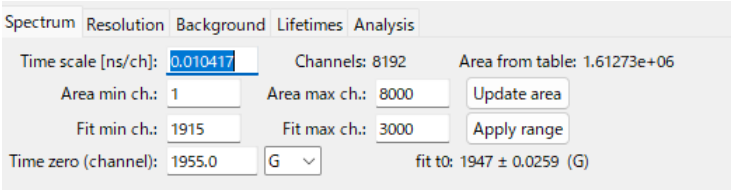
Displays the currently open spectrum file name and status such as analysis execution.



- mode : The status of Online or Offline mode will be displayed.
- file : The full path of the currently loaded data file will be displayed.
- analysis : The status of PositronFit or ResolutionFit will be displayed.
- Fit time : Displays the time taken for analysis.

7. 4. Spectrum tab

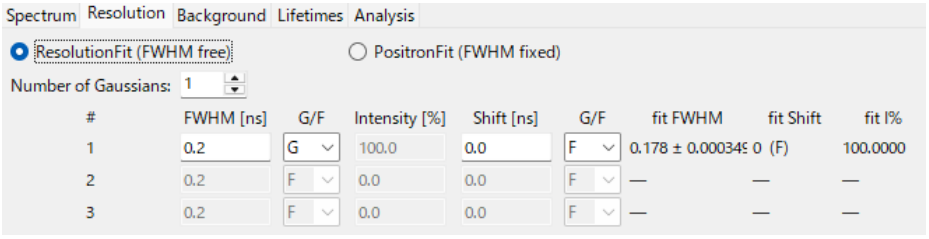
This screen sets the data range (ROI: Region of Interest) for checking measurement data, adjusting the timeline scale, and fitting.



- Time scale [ns/ch] : Time width per channel (channel width). This is a value different from the device's time resolution FWHM. It is automatically retrieved from CSV headers and similar sources (e.g., 0.010417 ns/ch).
- Channels [ch] : Total number of channels in the spectrum (e.g., 8192 channels). Automatically retrieved from the data.
- Area from table : The total number of counts within the Area range is displayed.
- Area min / max ch : Start and end channels for total count aggregation. The default is the full range (1 to 8192) .
- Update area : Update the Area range settings.
- Fit min / max ch : The analysis range (ROI) for performing least squares fitting. In the plot, Fit min is shown as a blue dashed line, and Fit max is shown as a green dashed line. Fit min/max is not set automatically. View the spectrum and enter it, then apply it with Apply range.
- Apply range : Apply the Fit analysis range settings.
- Time zero(channel) : Initial estimate of the time origin (peak position) where the positron entered (channel number). When opening the spectrum or pressing Apply range, it is automatically set from the count maximum position within the analysis range.
  - ➢ G : Guess
  - ➢ F : Fixed
- fit t0 (G or F) Displays the time origin (channel number) and standard deviation determined by fitting.

7. 5. Resolution tab

This screen defines the time resolution function (Instrument Response Function) of the measuring device and sets the estimation and fixation of parameters.

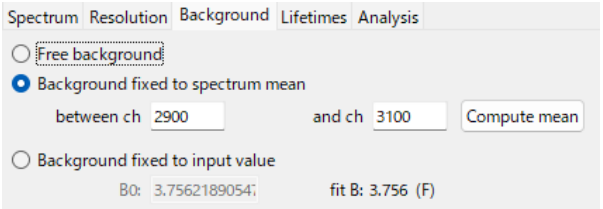


- ResolutionFit(FWHM free) : Variable and estimated resolution.
- PositronFit(FWHM fixed) : Fix the resolution.
- Number of Gaussians : Specify the number of Gaussian functions that make up the resolution function.
- FWHM (ns) : Half-width of a Gaussian function.
  - ➢ G : Guess
  - ➢ F : Fixed.In PositronFit, set it to F (fixed).
- Intensity(%) : The relative intensity ratio of each Gaussian function (total 100%). If there is only one Gaussian, it is fixed at 100%. The intensity of the first Gaussian is automatically determined as ″100% - (sum of the second and subsequent Gaussians)″ and cannot be entered. There is no G/F specification for intensity.
- Shift (ns) : Time deviation from peak position (offset). Initial value. The first Gaussian function is usually set to 0.0000 (fixed at F).
  - ➢ G : Guess
  - ➢ F : Fixed

  When running in ResolutionFit mode, you cannot set all Gaussian Shift functions to G (estimate) at the same time. To prevent uncertainty in origin movement, at least one Shift must be fixed at 0.0000 ns (F).
- fit FWHM : Here is the FWHM after analysis.
- fit Shift : This is a temporal deviation from the peak after analysis.
- fit I(%) : This is the relative intensity ratio after analysis.

7. 6. Background tab

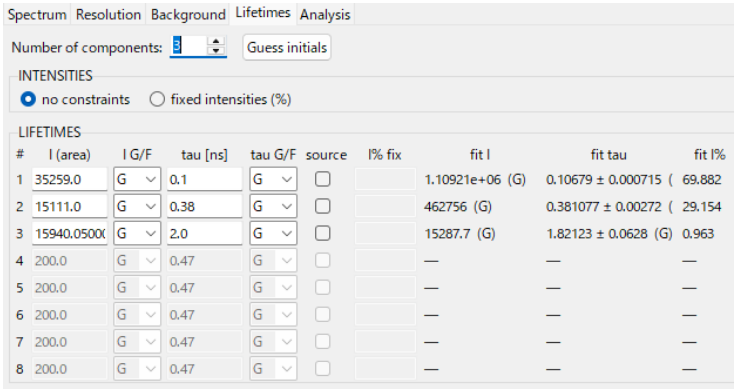
This screen sets the processing method for constant background caused by noise and environmental radiation.



- Free background : Background values are determined by fitting (G).
- Background fixed to spectrum mean : We pre-calculate the counting average for the specified channel range (e.g., 2900-3100 channels) and perform fitting based on that fixed value.
  - ➢ between ch (and ch) : Set the channel range.
- Background fixed to input value : Fix the background with the input fixed count value (e.g., 3.756).

7. 7. Lifetimes tab

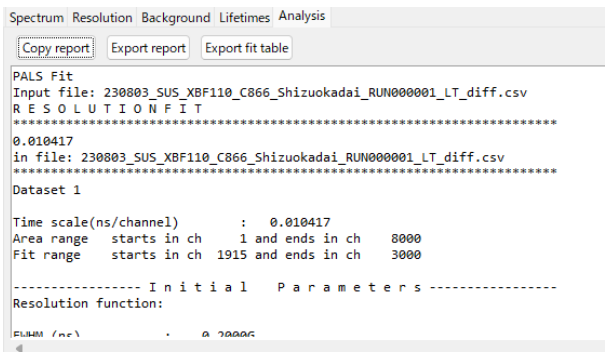
This screen sets constraints related to the number of lifetime components you want to physically extract, the initial lifetime value, relative intensity, and source correction.



- Number of components : Number of lifetime components to be fitted (1 to 8 components).
- Guess initials : The recommended initial value will be reflected in the settings.
- INTENSITIES : Regarding intensity constraints, we set the following two constraints for the intensity of the lifetime components.
  - no constraints : No constraints. In fitting calculations, there are no fixed values or physical rules imposed; the program freely searches for and calculates optimal values using least squares.
  - fixed intensities(%) : We perform fittings by directly fixing the relative intensity of specific lifetime components to specified values.
- LIFETIMES :
  - I(area) : Initial values of the intensity (area, count) of each component
  - I (G/F) : Usually, calculations are made freely in G (estimate), but it is also possible to fix specific components.
  - tau [ns] : The initial lifetime value (nanoseconds) of each component.
  - tau G/F : Set the initial tau value to G (estimate) for free fitting, and F (fix) to fix it at a constant value
  - source : If checked, the relevant component is treated as "components that have annihilated by the source, sealant, etc.," and the tau lifetime is forcibly fixed (F).
  - % fix : This is the field you can enter when you select fixed intensities (%). Enter the relative intensity (%) you want to fix.
  - fit I : Intensity after analysis (area, count) and G/F
  - fit tau : Lifetime (nanoseconds), standard deviation, G/F of each component after analysis.
  - fit I% : Relative intensity after analysis (%)

7. 8. Analysis tab

After least squares method fitting, the screen displays the text report. For how to read each item in the report (χ^2, degrees of freedom, standard deviation, etc.), please refer to the chapter on 'Principles of Analysis.'



Here is an example report

```
PAS-Analyzer
Input file: RUN000001_LT_diff.csv
R E S O L U T I O N F I T
*********************************************************************
0.010417
in file: RUN000001_LT_diff.csv
*********************************************************************
Dataset 1

Time scale(ns/channel)        :   0.010417
Area range   starts in ch     1 and ends in ch    8000
Fit range    starts in ch  1915 and ends in ch    3000

---------------I n i t i a l   P a r a m e t e r s ---------------
Resolution function:

FWHM (ns)           :    0.2000G
Intensities (%)     :  100.0000
Shifts (ns)         :    0.0000F

Time-zero(ch.no.) :  1955.0000

Lifetimes (ns)      :    0.1000G    0.3800G    2.0000G
Background fixed to mean from ch 2900 to ch 3100   =     3.7562

######################## F i n a l  r e s u l t s ######################

Convergence obtained after 11 function evaluations
Chi-square = 1192.64  with 1078 degrees of freedom
Reduced chi-square = Chi-square/dof =    1.106  with std deviation  0.043
---------------------------------------------------------------------
Resolution function:

FWHM (ns)           :    0.1780G
Std deviations      :     0.0003

Intensities (%)     :  100.0000

Shifts (ns)         :    0.0000F
Std deviations      :      fixed
---------------------------------------------------------------------
Lifetime components:

Lifetimes (ns)      :    0.1068    0.3811    1.8212
Std deviations      :    0.0007    0.0027    0.0628

Intensities (%)     :   69.8824   29.1545    0.9632
---------------------------------------------------------------------
Background (Counts/channel)   :     3.7562
Std deviation                 :       mean

Time-zero (Channel no.) :  1947.3966
Std deviation                 :     0.0259

Total area   From fit         : 1.59134E+06     From table : 1.61273E+06

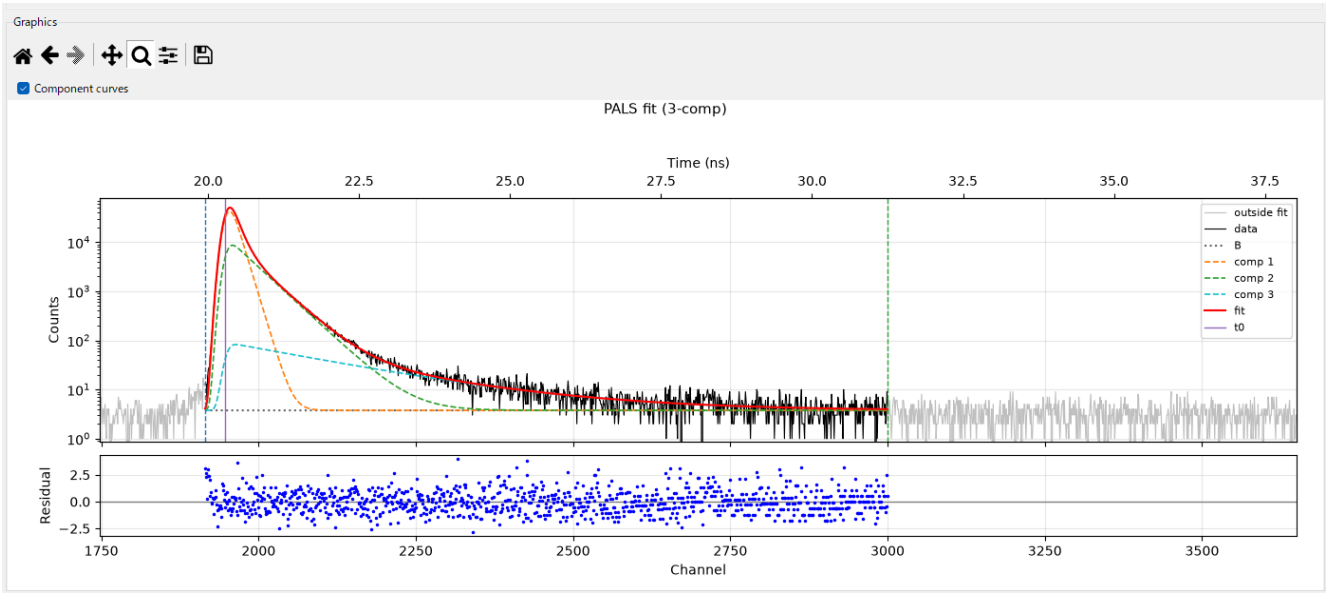
Shape parameters for resolution curve (ns):
             N        2        5       10       30      100      300     1000
FW   at     1/N   0.1780   0.2713   0.3245   0.3944   0.4589   0.5107   0.5621
MIDP at     1/N   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

Peak position of resolution curve: Channel # 1947.3966

Time for this job:    0.140 seconds.
```

7. 9. Graphics Field

This screen displays measurement data (black line), fitting composite curve (red line), individual lifetime component attenuation curves, and residual plots.



- Zoom / Pan Operation: You can zoom in and out with the mouse wheel and pan the range using the toolbar.
- X-axis display: Displays "Channel Number" on the bottom axis and "Time (ns)" on the top axis.
- Residual plot : Residual plot. Displays the normalized residual, which is the difference between the fit curve and the measurement data points divided by the standard deviation. Confirm that the residuals are randomly distributed around zero.
- Home / Back: Click Home on the toolbar to return to viewing all channels.. You can trace the zoom and movement history by going back/forward.
- When refitting: Even when running F5 with the zoom in, the horizontal axis display range is maintained. The vertical axis is automatically adjusted.
- Component curves : Checkboxes (below the toolbar) that display the curve and background B for each lifetime component.
- Gray line: Data outside the fit range.

7. 10. File

7. 10. 1. Spectral file

This is a lifetime spectrum file saved in the application PositronAnnihilationSystem.exe for the TechnoAP Positron Annihilation Lifetime Measurement Device. The file format is CSV (comma-separated text).
The available reading formats are as follows: Text is loaded in UTF-8.

- CSV (Device Type): Rows 1 to 16 are the header section (from [Header] to [Data]), and the first row from row 17 onward counts each channel (one row is one channel, the first is channel 1). The value of TimePerCh(ns) in the header is automatically entered into the Time scale.
- CSV (ch, count format): Without headers, the first column is the channel number (serial starting from 1), and the second column is the counting CSV. Time scale is not automatically included, so please enter it in the Spectrum tab.
- CSV (single-column format): This is a CSV where only the counts are arranged in a single column. The first 16 lines are skipped. Since Time Scale is not automatically entered, please enter it in the Spectrum tab.
- .dat : The first row is the time width (ns) per channel, and from the second row onward, count one line per channel. The value in the first row goes into the Time Scale.

```
[Header]
meas.start,2026/8/3,10:22:02
meas.end,2026/8/3,19:24:40
meas.time(s),2764800
elapsed time(s),32558
EnergyROICH1(ch),215,253
EnergyROICH2(ch),87,139
LifetimeROI(ch),1890,2700
input(cps),14136,21991
coincidence(cps),1310,1310
centroid(cps),226.48,111.15
throughput(cps),48
gross count,1589919
a,1
b,0
TimePerCh(ns),0.010417
[Data]
2,,
5,,
5,,
4,,
3,,
4,,
3,,
3,,
2,,
2,,
6,,
4,,
9,,
1,,
7,,
3,,
1,,
6,,

 :
*8,192 channels
```

7. 10. 2. Analysis Result File

Save analysis... This is the CSV file to save (the default file name is ″Spectral File Name_analysis.csv″). It can be opened in Excel. Open analysis... you can reload the analysis results, settings, and graphs from when you saved. The file consists of the following sections. Each section starts with the line ″# section″.

- Beginning (# line): Saved date and time, spectrum file name, Time scale, analysis settings (JSON), etc.
- fit_params : This is the parameter table for the analysis results. The columns are name, value, error, and GF.
- spectrum : This is the measurement spectrum. The columns are channel and counts.
- fit_curves : This is the curve of the graph. The columns are channel, time_ns, data, model, residual (normalized residual), background, and from component_1 onward (each lifetime component).
- report : This is the text of the report in the Analysis tab (one line is one cell).

The items for fit_params (name column) are as follows.

- I1, I2, … : The intensity of each component (area. counts).
- tau1, tau2, … : The lifetime of each component (ns).
- sigma : The standard deviation (ns) of the Gaussian resolution. FWHM = 2.355 × sigma.
- t0 : The time origin (ns).
- t0_ch : Time origin (channel number).
- B : Background (counts/ch).
- I1_fraction[%] : Relative intensity (%) of each component.
- FWHM : Half the width of the resolution (ns).
- chi2_red : Reduced chi-square.
- fit_time_s : Time (seconds) taken for fitting.
- GF Column: G is the estimated value, and F is the fixed value. error (standard deviation) is included only in the G field.
- (src) : Components ending with (src) in their names are source components that have been checked and fixed under the ″source″ checkbox.

Export fit table... The CSV saved is the output of only the table in this fit_params.

7. 10. 3. configuration file

Save config... This is the JSON file to be saved. It saves analysis settings such as analysis range, time scale, number of components, initial values and G/F for each parameter. Open config... and you can start analysis with the same settings.

8. Troubleshooting

8. 1. Unable to read the spectrum

"Failed to load spectrum" is displayed

- Reasons: The file does not have the corresponding format, or the count data cannot be found.
- Action: Please check the format in the "File" section under "Spectrum Files." If you open and save again in Excel or similar software, the format may change. Please try using the original file saved by your device.

Loadable, but the time scale doesn't match

- Reasons: If the header does not have a line for TimePerCh(ns) (ch, count format, single-column format), the Time scale will not be automatically added.
- Action: Enter the time span (ns) for one channel in the Time scale section of the Spectrum tab.

Missing data at the top, channel numbers not matching

- Reasons: A single-column CSV skips the first 16 lines.
- Action: Use ch,count format or add a 16-line header at the beginning.

Graphs do not update in Online mode

- Reasons: The specified file is either not updated or is in Offline mode.
- Action: Select Online from the File menu, and specify the file (Lifetime_Spectrum.csv) that the device application will update as Open spectrum... . To automatically fit each update, turn on Auto-fit on spectrum update in the Fit menu.

8. 2. Fitting is not working well

It displays "Open a spectrum first" or "Open a spectrum and set the fit range first"

- Reasons: Spectra are not loaded.
- Action: Please open a spectrum via File > Open spectrum.

"Fit failed" is displayed

- Reasons: If the analysis range (Fit min / max) or initial value is inappropriate, the calculation cannot be performed (e.g., too little data within the range).
- Action: Review Fit min / max and press Apply range. In the Lifetimes tab, use Guess initials to restore to the recommended default value, then run again.

Contains components with extremely short or long lifetimes, or nearly zero intensity

- Reasons: There are too many components.
- Action: Reduce the number of components. As a guideline, 2-3 components for metals and semiconductors, and up to 4 components for positronium-forming samples. Components with known lifetimes are stable when set to F (fixed).

Changing the initial value changes the result

- Reasons: Depending on the initial value, it converges to a different solution.
- Action: Change the initial value to 2 to 3 different ways and analyze to see if the result is the same. If it differs each time, reduce the number of components or fix some values.

Large standard deviation (±)

- Reasons: Components with close lifetimes influence each other.
- Action: Set either to F (fixed) or reduce the number of components.

FWHM Becomes Unnatural in ResolutionFit

- Reasons: The spectrum contains components that are difficult to distinguish from the device's resolution.
- Action: Run on the spectrum of a sample with essentially a single lifetime component (standard sample). Change the initial value and run again, then check if it converges to the same value.