Novel CDB Data Processing and Evaluation Software

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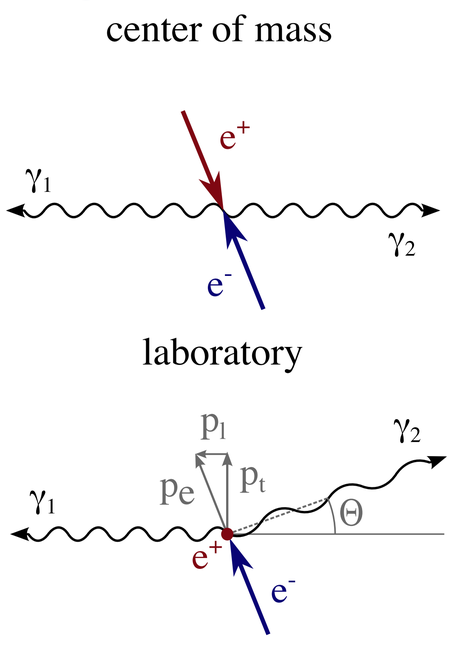
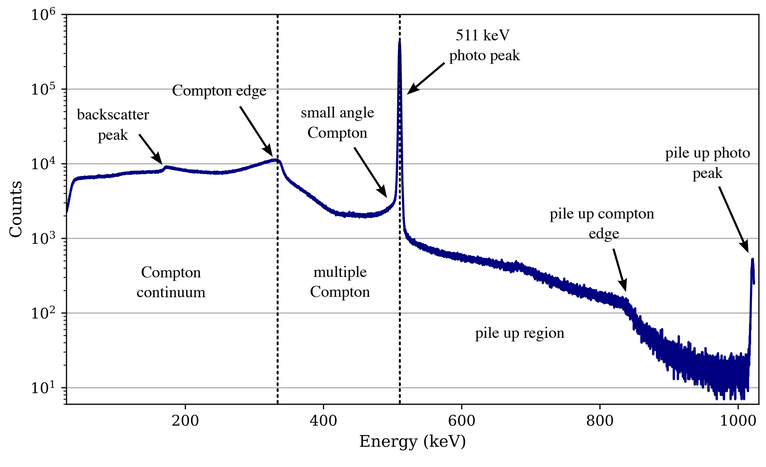
(C)DBS - (Coincident) Doppler Broadening Spectroscopy

DBS

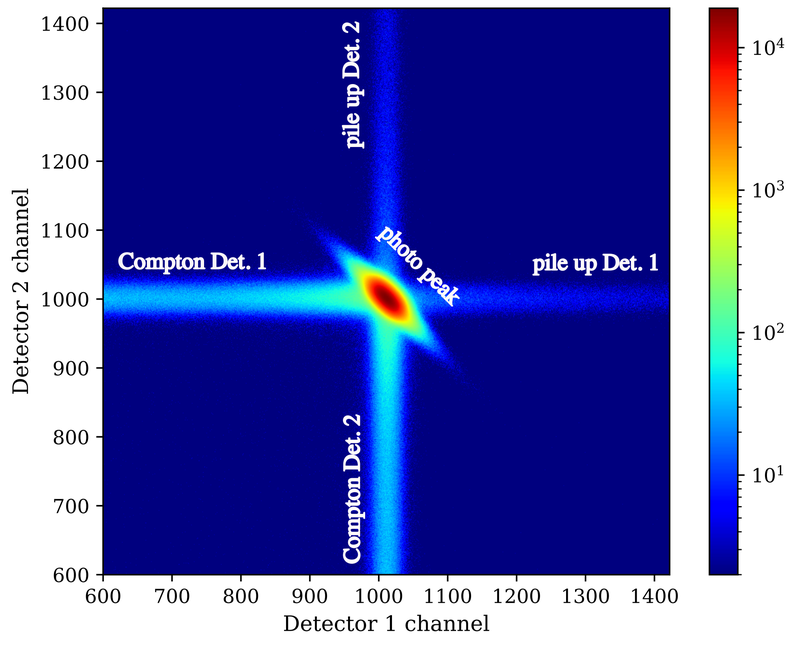


DB spectra are comprised of the energy spectum of the positron electron annihilation, measured with a single detector. In order to improve the signal-to-noise ratio of the Doppler broadened $511\ \mathrm{keV}$ photo peak both annihilation γ-quanta are measured. The resulting **C**DB data is 2 dimensional.

Single Spectrum

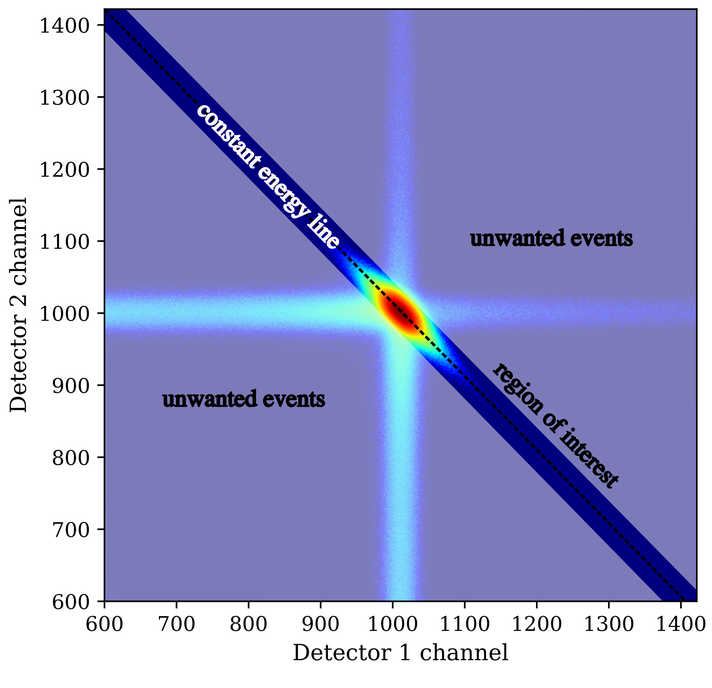


Coincidence Spectrum



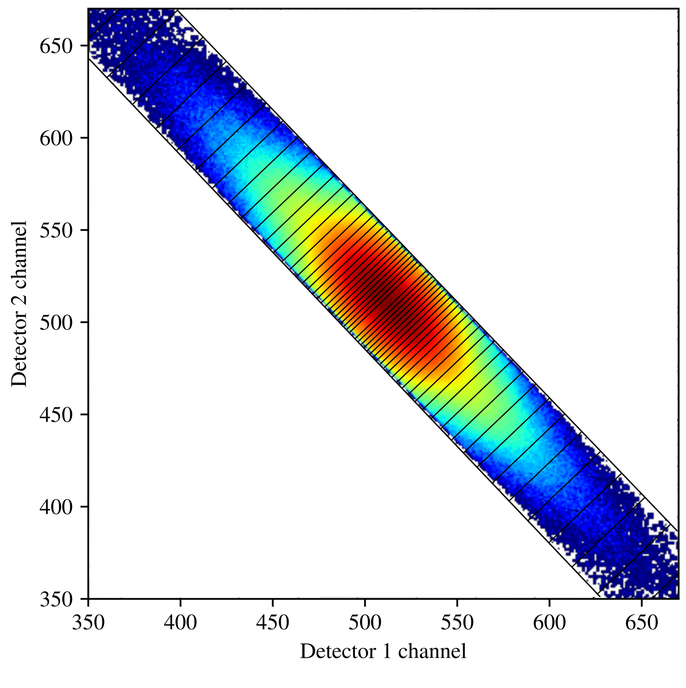
STACS - Software to Analyze CDB Spectra

Region of Interest



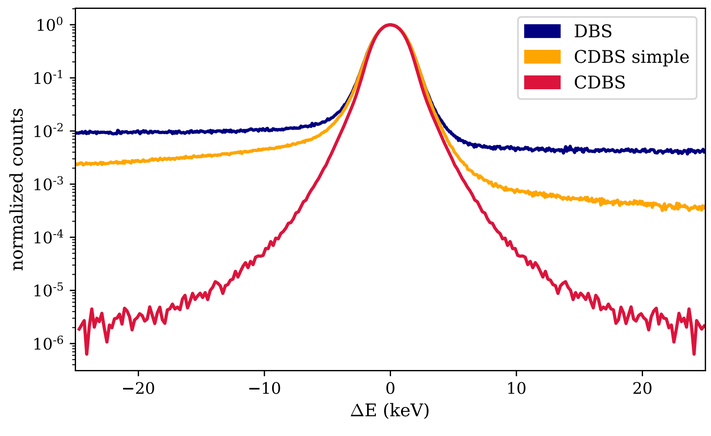
- Easy to implement and computationally fast.
- With our improved background subtraction we yield a signal-to-background ratio of up to seven orders of magnitude.

Energy Binning



- Cutting through pixels with linear interpolation.
- Bin widths can be altered by user; for example wider bins can improve statistics at the cost of energy resolution.

Projection

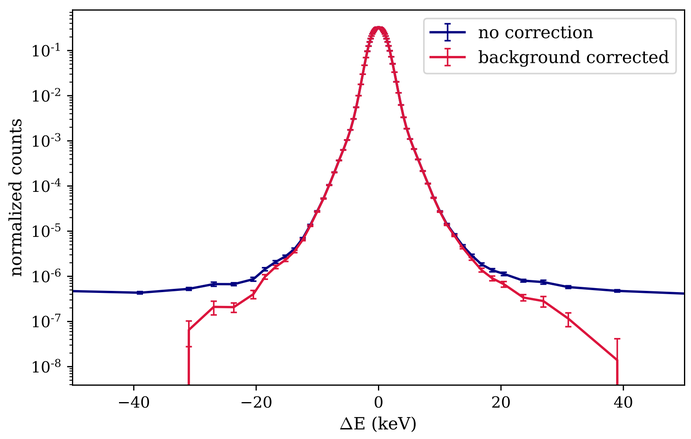


Software Features

- Modular python package - easy to use / adapt / improve.
- Fast computation (∼few sec per projection).
- Includes background subtraction and several plotting features for displaying measurements, including the ability to create ratio curves or 2D histograms.
- First ever mutli detector CDB evaluation method with the ability to construct averaged projections from multiple detector pairs.
- Currently preliminary version, beta version will be released as an open source package.

Example Measurements

Background Subtraction Benchmark



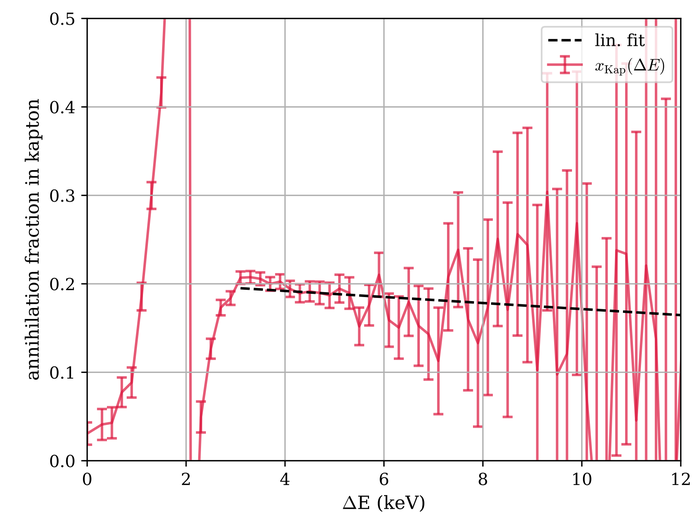
- Performend on W single crystal provided by Annemarie Kärcher of the Max Planck Institute for Plasma Physics.
- Background subtraction makes doppler shifts larger than $30\ \mathrm{keV}$ visible.

Annihilation Fraction in Kapton using a ^{22}Na Source

The positron annihilation fraction in Kapton during a CDBS measurement of Cu samples surrounding a ^{22}Na source (sandwich geonetry) is calculated by comparing with a NEPOMUC beam measurement on Cu. Both experiments are performed at the CDB spectrometer at FRM II. $x_{\mathrm{Kap}}(\Delta E)$ represents the doppler shift dependent annihilation fraction of positrons in the $\sim 25\ \mu\mathrm{m}$ thick Kapton source enclosure.

$$x_{\mathrm{Kap}}(\Delta E) = \frac{p_{\mathrm{s}}^{\mathrm{Cu}}(\Delta E) - p_{\mathrm{b}}^{\mathrm{Cu}}(\Delta E)}{p_{\mathrm{s}}^{\mathrm{Kap}}(\Delta E) - p_{\mathrm{b}}^{\mathrm{Cu}}(\Delta E)},$$

where p represents the projection as a result of a CDB measurement, b and s represent beam and source measurements respectively.
The large variance of values between 0 and $3\ \mathrm{keV}$ is a result of the shape of the photo peak projections. The annihilation fraction can be calculated by averaging the values from 3 to $10\ \mathrm{keV}$ and results in $x_{\mathrm{Kap}} = (19.8 \pm 3.2)\ \%$. This analysis enables reliable comparisons of beam and source measurements in the future.



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