

# 氫硼核融合實作

## Practical course on proton-boron nuclear fusion

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**Po-Yu Chang ( pchang@mail.ncku.edu.tw )**

**Institute of Space and Plasma Sciences, National Cheng Kung University**

**2025 summer break**

**7/14(Mon.) – 7/18(Fri.) 14:00-17:40**

**Lecture 4**

**<https://capst.ncku.edu.tw/PGS/index.php/teaching/>**

# Final presentation



**On Friday, 5 mins presentation for each person (20 %):**

- 1. How did you analyze the data.**
- 2. The histogram table.**
- 3. The histogram plot.**
- 4. Provide the histogram table in excel.**

**Final writing report (20 %):**

- 1. 實驗設備之原理。**
- 2. 數據分析原理說明。**
- 3. 數據分析結果。**
- 4. 討論。**

**若週四實驗課缺課，則報告為0分。**

- From the histogram plot and table:**
  - If energy loss of the proton generated from the DD fusion is neglected, what is the energy of T and  $^3\text{He}$ ?**
  - What's the peak energy of alphas from p-B fusion?**

# Final presentation

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- **Every student will analyze one set of p-B fusion data and D-D fusion data.**
  - **The data set is assigned to each student.**
  - **Data needs to be converted from psdata format to csv format.**
  - **Analyze the data. A excel file and a figure is generated.**
  - **Generate the histogram plot and table.**
    - **p-B fusion: 0~20, each bin has a width of 0.4, i.e., 50 bins.**
    - **DD fusion: 0~6, each bin has a width of 0.01, i.e., 600 bins.**
- **The analyzing program is provided. Student can pick either the matlab code or the python code to analyze the data.**

# Provided programs



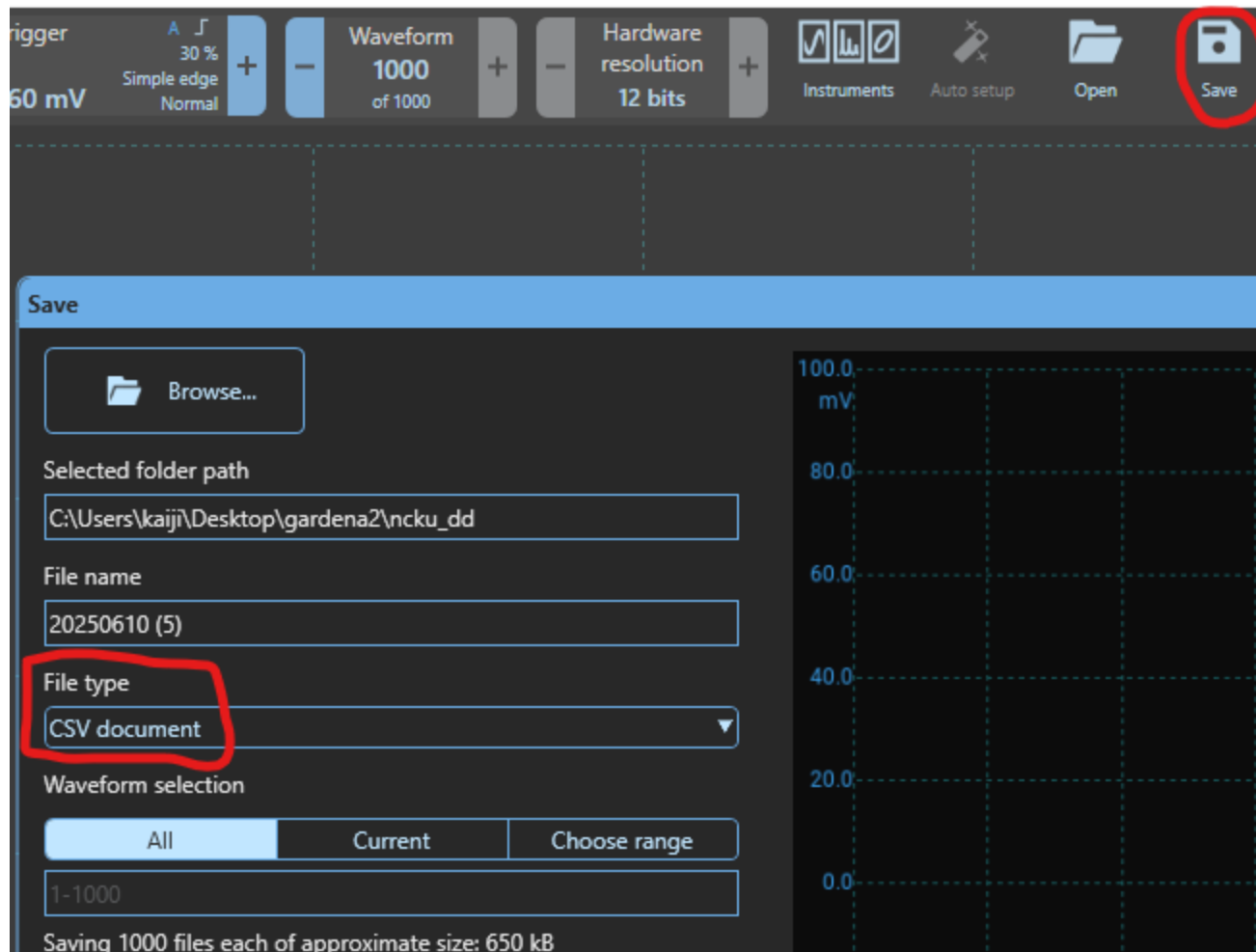
- The analyzing program is provided. Student can pick either the matlab code or the python code to analyze the data.
- The converting program “PicoScope\_7\_TandM\_7.1.50.5777.exe” is provided.
- Table of assigned data set:

| Students | p-B fusion          | D-D fusion   |
|----------|---------------------|--------------|
| 陳崇文      | 75keV_30Hz_5pct(20) | 20250610(20) |
| 許哲瑜      | 75keV_30Hz_5pct(21) | 20250610(21) |
| 許源凱      | 75keV_30Hz_5pct(22) | 20250610(22) |
| 劉于華      | 75keV_30Hz_5pct(23) | 20250610(23) |
| 黃雅筠      | 75keV_30Hz_5pct(24) | 20250610(24) |
| 盧宣嘉      | 75keV_30Hz_5pct(25) | 20250610(25) |
| 廖奕涵      | 75keV_30Hz_5pct(26) | 20250610(26) |
| 關運澤      | 75keV_30Hz_5pct(27) | 20250610(27) |
| 葉柏廷      | 75keV_30Hz_5pct(28) | 20250610(28) |
| 賴資佳      | 75keV_30Hz_5pct(29) | 20250610(29) |
| 李政穎      | 75keV_30Hz_5pct(30) | 20250610(30) |

# psdata is converted to csv using PicoScope program



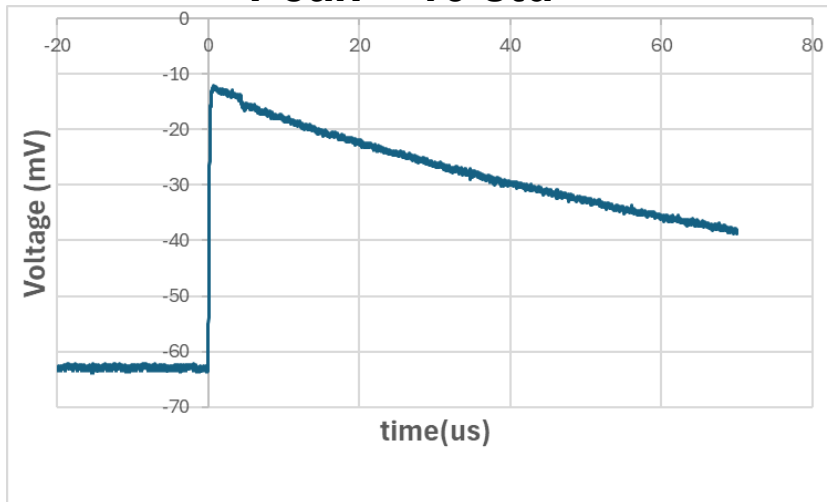
PicoScope\_7\_TandM\_7.1.50.5777.exe



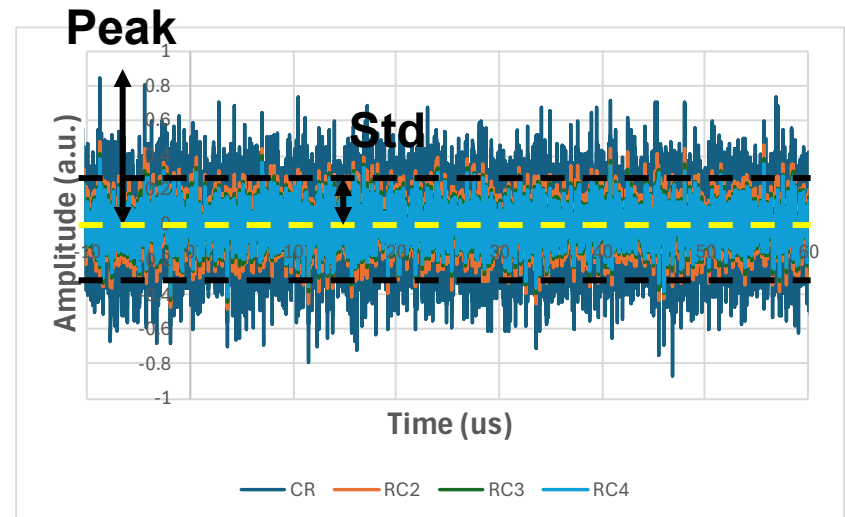
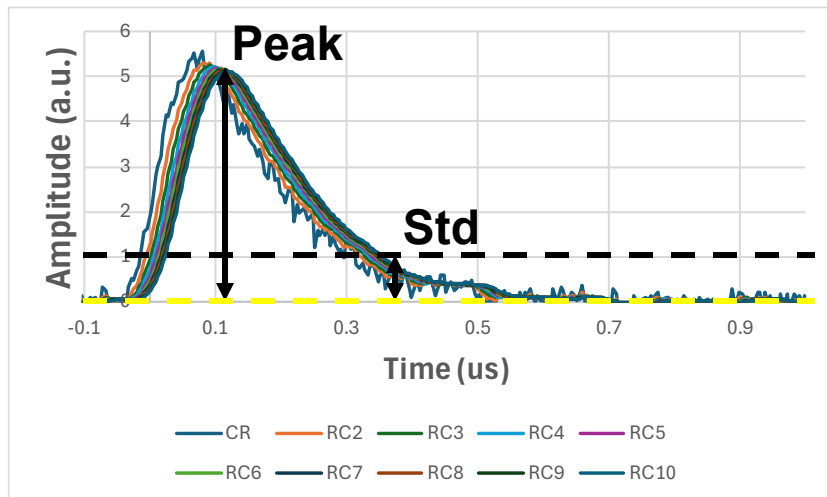
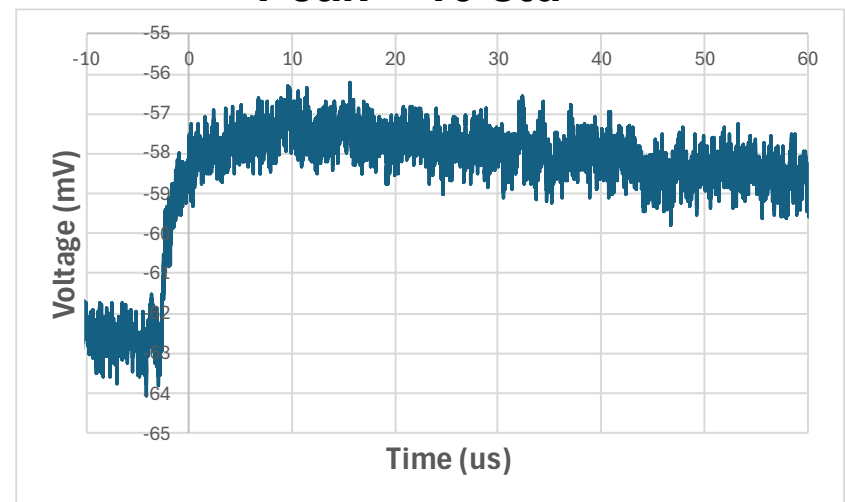
# Data is saved when the peak is 10 times larger than the standard deviation



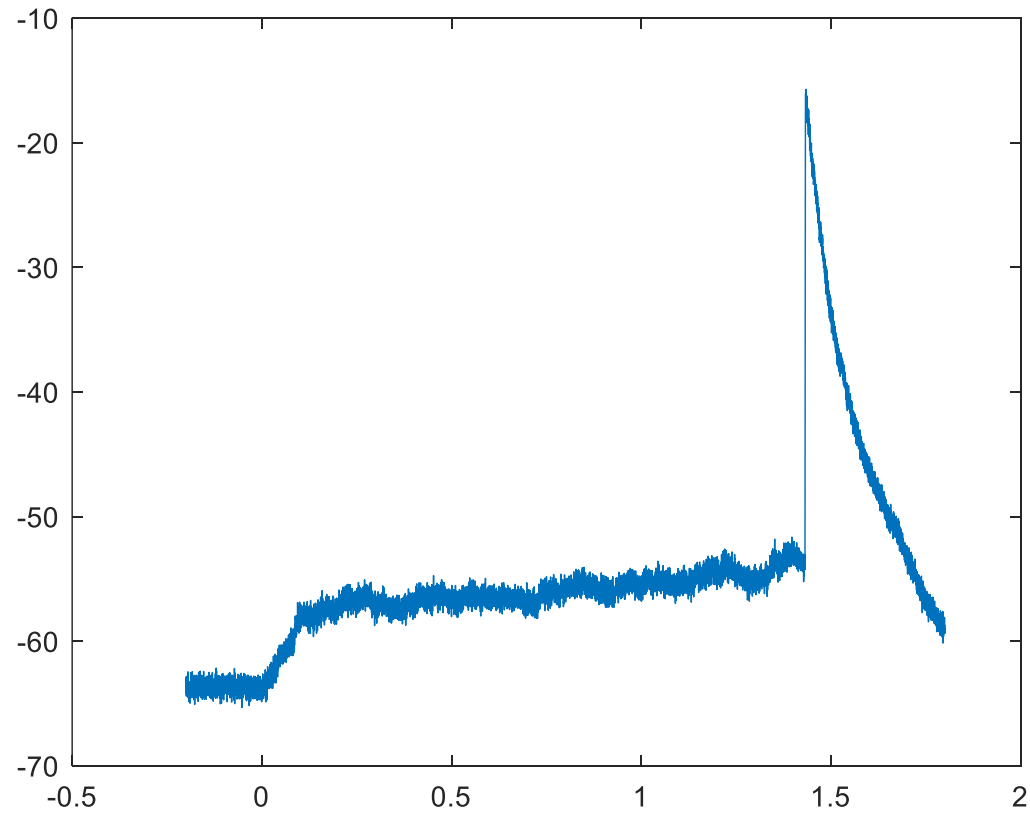
## Peak > 10 std



## Peak < 10 std



# The signal may be mixed with the noise



# Generate histogram using excel - 1



Excel interface showing a spreadsheet with data for generating a histogram. The file name is 20250610(10)\_wHistogram - 複製.xlsx. The ribbon includes tabs like 檔案 (File), 常用 (Home), 插入 (Insert), 繪圖 (Draw), 頁面配置 (Layout), 公式 (Formulas), 資料 (Data), 校閱 (Review), 檢視 (View), 自動化 (Automation), 增益集 (Add-ins), 說明 (Help), and COMSOL 6.0. The 檔案 (File) tab is highlighted.

The spreadsheet data is as follows:

| Energy(a.u.) | folder | eventNumber | Bin  |
|--------------|--------|-------------|------|
| 4.762369     | 10     | 1           | 0.01 |
| 0.8981926    | 10     | 2           | 0.02 |
| 4.857612     | 10     | 3           | 0.03 |
| 1.44137      | 10     | 4           | 0.04 |
| 0.9083873    | 10     | 5           | 0.05 |
| 4.866261     | 10     | 6           | 0.06 |
| 1.363468     | 10     | 7           | 0.07 |
| 4.809048     | 10     | 8           | 0.08 |
| 1.64176      | 10     | 9           | 0.09 |
| 0.9106567    | 10     | 10          | 0.1  |
| 1.566556     | 10     | 11          | 0.11 |
| 4.449653     | 10     | 12          | 0.12 |
| 4.71235      | 10     | 13          | 0.13 |
| 0.9443364    | 10     | 14          | 0.14 |
| 4.865753     | 10     | 15          | 0.15 |
| 4.810346     | 10     | 16          | 0.16 |
| 4.82144      | 10     | 17          | 0.17 |
| 4.732153     | 10     | 18          | 0.18 |
| 4.851197     | 10     | 19          | 0.19 |
| 4.915464     | 10     | 20          | 0.2  |
| 1.574656     | 10     | 21          | 0.21 |
| 0.972246     | 10     | 22          | 0.22 |
| 0.7761735    | 10     | 23          | 0.23 |
| 4.829608     | 10     | 24          | 0.24 |
| 1.59033      | 10     | 25          | 0.25 |
| 4.763879     | 10     | 26          | 0.26 |
| 1.536165     | 10     | 27          | 0.27 |

The status bar at the bottom indicates 就緒 (Ready) and 協助工具: 一切準備就緒 (Help: Everything is ready).

# Generate histogram using excel - 2



20250610(10)\_wHistogram - 複製.xlsx

← 常用

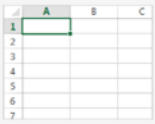
新增 開啟 共用

資訊 儲存檔案 另存新檔 列印 匯出 關閉

COMSOL 帳戶 選項

## 早安

▼ 新增



空白活頁簿



歡迎使用 Excel



開始使用 公式



製作您的第一個 樞紐分析表



甘特圖專案規劃工具



每週排程規劃工具



里程碑資訊圖表時間表

更多範本 →

搜尋

最近 我的最愛 與我共用

| 名稱                                                                                                                                                       | 修改日期   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
|  20250610(10)_wHistogram - 複製.xlsx<br>X: > CPU_Collected > ncku_dd      | 剛剛     |
|  20250610(10)_wHistogram.xlsx<br>X: > CPU_Collected > ncku_dd          | 剛剛     |
|  75keV_30Hz_5pct(5).xlsx<br>X: > CPU_Collected > pB_demo_psdata       | 18 分鐘前 |
|  75keV_30Hz_5pct(4).xlsx<br>X: > CPU_Collected > pB_demo_psdata       | 18 分鐘前 |
|  75keV_30Hz_5pct(3).xlsx<br>X: > CPU_Collected > pB_demo_psdata       | 19 分鐘前 |
|  75keV_30Hz_HistogramTest.xlsx<br>X: > CPU_Collected > pB_demo_psdata | 34 分鐘前 |

# Generate histogram using excel - 3



Excel 選項

一般  
公式  
資料  
校訂  
儲存  
語言  
協助工具  
進階  
自訂功能區  
快速存取工具列  
**增益集**  
信任中心

檢視與管理 Microsoft Office 增益集。

增益集

| 名稱 ^                                           | 位置                                                 | 類型        |
|------------------------------------------------|----------------------------------------------------|-----------|
| 作用中應用程式增益集                                     |                                                    |           |
| COMSOL 6.0                                     | file:///C:/Program Files/COMSOL/COMSOL60\Mul       | COM 增益集   |
| National Instruments TDM Importer for MS Excel | C:\Program Files\National Instruments\Shared\TD    | COM 增益集   |
| 中文繁體轉換增益集                                      | C:\Program Files\Microsoft Office\root\Office16\A  | COM 增益集   |
| <b>分析工具箱</b>                                   | C:\Program Files\Microsoft Office\root\Office16\Li | Excel 增益集 |
| 非作用中應用程式增益集                                    |                                                    |           |
| Euro Currency Tools                            | C:\Program Files\Microsoft Office\root\Office16\Li | Excel 增益集 |
| Inquire                                        | C:\Program Files (x86)\Microsoft Office\Office16\  | COM 增益集   |
| Microsoft Actions Pane 3                       |                                                    | XML 擴充套件  |
| Microsoft Data Streamer for Excel              | C:\Program Files\Microsoft Office\root\Office16\A  | COM 增益集   |
| Microsoft Power Map for Excel                  | C:\Program Files\Microsoft Office\root\Office16\A  | COM 增益集   |
| Microsoft Power Pivot for Excel                | C:\Program Files\Microsoft Office\root\Office16\A  | COM 增益集   |

增益集: COMSOL 6.0  
發行者: <無>  
相容性: 沒有相容性資訊可提供  
位置: file:///C:/Program Files/COMSOL/COMSOL60\Multiphysics\ext\LiveLink\Excel\\LiveLinkForExcel.vsto\dstolocal  
描述: COMSOL LiveLink for Excel

管理(A): Excel 增益集 執行(G)...

確定 取消

# Generate histogram using excel - 4



Excel interface showing the 'Data' (資料) tab selected in the ribbon. The 'Data Analysis' (資料分析) tool is highlighted in the ribbon. The spreadsheet displays a table with columns: Energy(a.u.), folder, eventNumber, and Bin. The data is sorted by Bin, ranging from 0.01 to 0.27.

|    | A            | B      | C           | D | E  | F    | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W |
|----|--------------|--------|-------------|---|----|------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1  | Energy(a.u.) | folder | eventNumber |   |    | Bin  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 2  | 4.762369     | 10     | 1           |   | 1  | 0.01 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 3  | 0.8981926    | 10     | 2           |   | 2  | 0.02 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 4  | 4.857612     | 10     | 3           |   | 3  | 0.03 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 5  | 1.44137      | 10     | 4           |   | 4  | 0.04 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 6  | 0.9083873    | 10     | 5           |   | 5  | 0.05 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 7  | 4.866261     | 10     | 6           |   | 6  | 0.06 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 8  | 1.363468     | 10     | 7           |   | 7  | 0.07 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 9  | 4.809048     | 10     | 8           |   | 8  | 0.08 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 10 | 1.64176      | 10     | 9           |   | 9  | 0.09 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 11 | 0.9106567    | 10     | 10          |   | 10 | 0.1  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 12 | 1.566556     | 10     | 11          |   | 11 | 0.11 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 13 | 4.449653     | 10     | 12          |   | 12 | 0.12 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 14 | 4.71235      | 10     | 13          |   | 13 | 0.13 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 15 | 0.9443364    | 10     | 14          |   | 14 | 0.14 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 16 | 4.865753     | 10     | 15          |   | 15 | 0.15 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 17 | 4.810346     | 10     | 16          |   | 16 | 0.16 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 18 | 4.82144      | 10     | 17          |   | 17 | 0.17 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 19 | 4.732153     | 10     | 18          |   | 18 | 0.18 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 20 | 4.851197     | 10     | 19          |   | 19 | 0.19 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 21 | 4.915464     | 10     | 20          |   | 20 | 0.2  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 22 | 1.574656     | 10     | 21          |   | 21 | 0.21 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 23 | 0.972246     | 10     | 22          |   | 22 | 0.22 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 24 | 0.7761735    | 10     | 23          |   | 23 | 0.23 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 25 | 4.829608     | 10     | 24          |   | 24 | 0.24 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 26 | 1.59033      | 10     | 25          |   | 25 | 0.25 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 27 | 4.763879     | 10     | 26          |   | 26 | 0.26 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 28 | 1.536165     | 10     | 27          |   | 27 | 0.27 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

# Generate histogram using excel - 5



COMSOL 6.0

檔案 常用 插入 繪圖 頁面配置 公式 資料 校閱 檢視 自動化 增益集 說明

取得資料 從文字/CSV 從 Web 從表格/範圍 來自圖片(F) 最近使用的來源 現有連線 取得及轉換資料

查詢與連線 全部重新整理 內容 活頁簿連結

資料類型 股票 (Engli... 貨幣 (Engli...

排序與篩選 排序 篩選 清除 重新套用 進階...

資料工具 資料剖析 模擬分析 預測 工作表

組組成群組 取消群組 小計 大綱 分析

註解 共用

M17

|    | A            | B      | C           | D | E  | F    | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W |
|----|--------------|--------|-------------|---|----|------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1  | Energy(a.u.) | folder | eventNumber |   |    | Bin  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 2  | 4.762369     | 10     | 1           |   | 1  | 0.01 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 3  | 0.8981926    | 10     | 2           |   | 2  | 0.02 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 4  | 4.857612     | 10     | 3           |   | 3  | 0.03 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 5  | 1.44137      | 10     | 4           |   | 4  | 0.04 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 6  | 0.9083873    | 10     | 5           |   | 5  | 0.05 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 7  | 4.866261     | 10     | 6           |   | 6  | 0.06 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 8  | 1.363468     | 10     | 7           |   | 7  | 0.07 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 9  | 4.809048     | 10     | 8           |   | 8  | 0.08 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 10 | 1.64176      | 10     | 9           |   | 9  | 0.09 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 11 | 0.9106567    | 10     | 10          |   | 10 | 0.1  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 12 | 1.566556     | 10     | 11          |   | 11 | 0.11 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 13 | 4.449653     | 10     | 12          |   | 12 | 0.12 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 14 | 4.71235      | 10     | 13          |   | 13 | 0.13 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 15 | 0.9443364    | 10     | 14          |   | 14 | 0.14 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 16 | 4.865753     | 10     | 15          |   | 15 | 0.15 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 17 | 4.810346     | 10     | 16          |   | 16 | 0.16 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 18 | 4.82144      | 10     | 17          |   | 17 | 0.17 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 19 | 4.732153     | 10     | 18          |   | 18 | 0.18 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 20 | 4.851197     | 10     | 19          |   | 19 | 0.19 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 21 | 4.915464     | 10     | 20          |   | 20 | 0.2  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 22 | 1.574656     | 10     | 21          |   | 21 | 0.21 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 23 | 0.972246     | 10     | 22          |   | 22 | 0.22 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 24 | 0.7761735    | 10     | 23          |   | 23 | 0.23 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 25 | 4.829608     | 10     | 24          |   | 24 | 0.24 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 26 | 1.59033      | 10     | 25          |   | 25 | 0.25 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 27 | 4.763879     | 10     | 26          |   | 26 | 0.26 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 28 | 1.536165     | 10     | 27          |   | 27 | 0.27 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

Sheet1

就緒 協助工具: 一切準備就緒

資料分析

分析工具(A)

- 雙因子變異數分析: 無重複試驗
- 相關係數
- 共變數
- 敘述統計
- 指數平滑法
- F-檢定: 兩個常態母體變異數的檢定
- 傅立葉分析
- 直方圖
- 移動平均法
- 亂數產生器

確定 取消 說明(H)

# Generate histogram using excel - 6



Excel interface showing the 'Histogram' dialog box. The data is from '20250610(10)\_wHistogram - 複製.xlsx'.

The data table (Sheet1) is as follows:

| Energy(a.u.) | folder | eventNumber | Bin  |
|--------------|--------|-------------|------|
| 4.762369     | 10     | 1           | 0.01 |
| 0.8981926    | 10     | 2           | 0.02 |
| 4.857612     | 10     | 3           | 0.03 |
| 1.44137      | 10     | 4           | 0.04 |
| 0.9083873    | 10     | 5           | 0.05 |
| 4.866261     | 10     | 6           | 0.06 |
| 1.363468     | 10     | 7           | 0.07 |
| 4.809048     | 10     | 8           | 0.08 |
| 1.64176      | 10     | 9           | 0.09 |
| 0.9106567    | 10     | 10          | 0.1  |
| 1.566556     | 10     | 11          | 0.11 |
| 4.449653     | 10     | 12          | 0.12 |
| 4.71235      | 10     | 13          | 0.13 |
| 0.9443364    | 10     | 14          | 0.14 |
| 4.865753     | 10     | 15          | 0.15 |
| 4.810346     | 10     | 16          | 0.16 |
| 4.82144      | 10     | 17          | 0.17 |
| 4.732153     | 10     | 18          | 0.18 |
| 4.851197     | 10     | 19          | 0.19 |
| 4.915464     | 10     | 20          | 0.2  |
| 1.574656     | 10     | 21          | 0.21 |
| 0.972246     | 10     | 22          | 0.22 |
| 0.7761735    | 10     | 23          | 0.23 |
| 4.829608     | 10     | 24          | 0.24 |
| 1.59033      | 10     | 25          | 0.25 |
| 4.763879     | 10     | 26          | 0.26 |
| 1.536165     | 10     | 27          | 0.27 |

The 'Histogram' dialog box is open, showing the following options:

- 輸入範圍(I): [Input Range]
- 組界範圍(B): [Bin Range]
- ☐ 標記(L)
- 輸出選項:
  - ☐ 輸出範圍(Q): [Output Range]
  - ☒ 新工作表(P): [New Worksheet]
  - ☐ 新活頁簿(W)
- ☐ 柏拉圖 (經排序的直方圖)(A)
- ☐ 累積百分率(M)
- ☒ 圖表輸出(C)

Buttons: 確定, 取消, 說明(H)

# Generate histogram using excel - 7

