

PhIAT Documentation -- Manual Fitting

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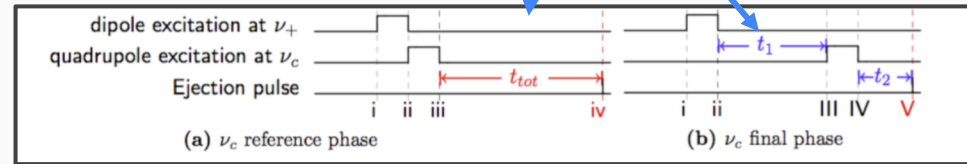
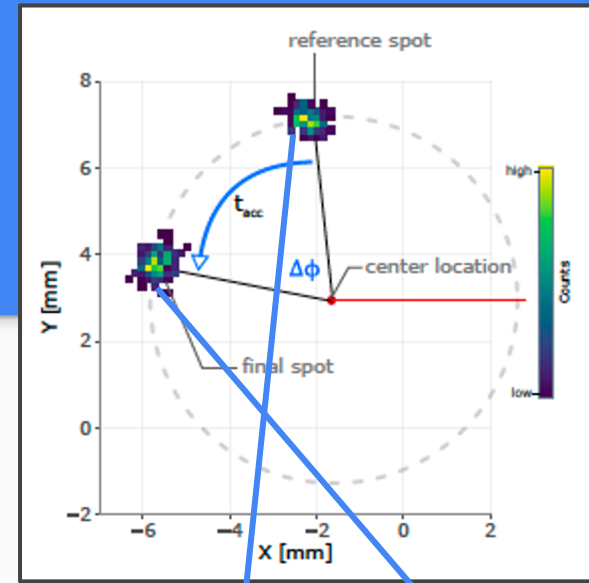
TRIUMF, on behalf of the TITAN Collaboration

Overview

- **Language:** MATLAB (R2016a or newer)
- **Input:** A directory address (i.e. address to a folder) of MIDAS Files (ex: `/Users/wsporter/Documents/Physics_Research/TITAN/PIICR_Analysis/Testing/Test_CAENOffset`) OR a File List.csv (see midas_to_phiat Documentation for more)
- **Output:**
 - A .csv containing relevant info and potential cyclotron frequencies of spots in all files (if Create Freq ID checked)
 - A .xlsx containing relevant data fitting results (if Finish Analysis checked)
 - A .png of the sinusoidal fit of cyclotron frequency data (if Finish Analysis checked)
 - A .png of the sinusoidal fit of radius data (if Finish Analysis checked)

PI-ICR Basics

- The cyclotron frequency (ω_c) is determined via the phase difference (ϕ_c) between two spots with different **accumulation times (T_{acc})**
 - Reference Spot: $T_{acc} = 0$
 - Final Spot: $T_{acc} = \text{Nonzero Value}$
- PhIAT determines the X/Y Positions of these spots to find each of their phases



$$\omega_c = \frac{\phi_c + 2\pi N(t_{acc})}{2\pi t_{acc}}$$

BEFORE YOU CONTINUE! -- titan_data

- PhIAT.m uses midas_to_phiat.py, which requires you download the **titan_data package**
 - This can be downloaded here: https://bitbucket.org/ttriumfdaq/titan_data/src/master/
- On Line 20 in midas_to_phiat.py: Change the address in sys.path.append from `'/Users/wsporter/Documents/Physics_Research/TITAN/PIICR_Analysis/titan_data'` to the local address of titan_data on your computer (i.e. `'/local/address/to/titan_data'`)

```
sys.path.append('/Users/wsporter/Documents/Physics_Research/TITAN/PIICR_Analysis/titan_data') # Address of titan_data module. NEW USERS NEED TO CHANGE THIS! #
```

NOTE!

- A large portion of this method of fitting is similar to Automatic Fitting, and therefore only differences are documented here. Please reference the Automatic Fitting documentation for a full description of the analysis suite

Getting Started

- Press the Run Button to bring up the PhiAT GUI:

PhiAT v1.0

N Range 10 ID Spot

Automatic Fitting

Directory of Midas Files (or TacList.csv): ~/path/to/files

Target File Location: ~/path/to/store/saved/results/

Isotope: 130Cs

Time in Trap: 250ms

Date Taken: 2016-07-21

Cyclotron Frequency Guess (Hz): 114900.4300000

Spot Angle (-180° to 180°): -30

Load List of Files

Automatic Fit

Systematics

☐ Create Freq ID

☐ Impure Beam Angle Correction

☐ Finish Analysis

☐ Phase Cutoff 10

Trap Center X: -2.31

Trap Center Y: 2.83

Magnetron Frequency (Hz): 1683

Points per Cluster: 20

Spot Bandwidth: 1.25

Load File

Raw Data File (.csv): /Users/macuser/Documents/Physics_Research/ANL_

Number of Ions: 1,111,111

% of Total

Edit Text

Ion Rate (Hz): 2,222,222

☐ Sim Ion Rate

Recalculate Square Fit

Recalculate Radial Fit

Save Fits and Graphs

Create Center Spot Redux CSV

Save Angles and Radii

Center Spot Redux (.csv): /Users/macuser/Documents/Physics_Research/ANL_

Radius List (.csv): /Users/macuser/Documents/Physics_Research/ANL_

Finish Analysis

Radial Fit and Bounds

X Center: -1.5

Y Center: 3.0

Fit Radius: 1.0

Current X-Y Graph

Time of Flight

Current X Distribution

Angular Distribution

Current Y Distribution

Radial Distribution

T Distribution Fit and Bounds

Lower Bound: -300000

Upper Bound: 0

ToF Center: -10

ToF Error: -10

A Distribution Fit and Bounds

Lower Bound: 0

Upper Bound: 360

Angle Center: -10

Angle Error: -10

Shift 30 Degrees Clockwise

Shift 30 Degrees Counterclockwise

R Distribution Fit and Bounds

Lower Bound: 0

Upper Bound: 10

Radius Center: -10

Radius Error: -10

Loading a List of Files

- To start, input the address of the directory of MIDAS files (i.e. `/Users/wsporter/Documents/Physics_Research/TITAN/PIICR_Analysis/Testing/Test_CAENOffset`)
 - If you have already converted a directory of MIDAS files using `midas_to_phiat.py`, you can also input the address of the `FileList.csv` (see `midas_to_phiat.py` documentation)
- Click the Load List of Files button...

Automatic Fitting

Directory of Midas Files (or FileList.csv)	~/path/to/files
Target File Location	~/path/to/store/saved/results/
Isotope	¹³⁰ Cs
Time in Trap	300ms
Date Taken	2016-07-21
Cyclotron Frequency Guess (kHz)	114000.4300000
Spot Angle (180° to 180°)	-30

Load List of Files

Automatic Fit

Loading a List of Files cont.

- Clicking Load List of Files runs `midas_to_phiat.py` and converts each MIDAS file into a readable `.csv` file containing (for each event):
 - X/Y Positions
 - Times of Flight from Ejection to MCP Contact
 - What trigger number of the TDC each event was recorded during
- `midas_to_phiat.py` also creates a `FileList.csv`, which contains a list of addresses of all data files

Automatic Fitting

Directory of Midas Files (or FileList.csv)	~/path/to/files
Target File Location	~/path/to/stored/results/
Isotope	¹³³ Cs
Time in Trap	200ms
Date Taken	2016-07-21
Cyclotron Frequency Sweep (Hz)	114000.000000
Spot Angle (180° to 180°)	-30

Load List of Files Automatic Fit

Loading a List of Files cont.

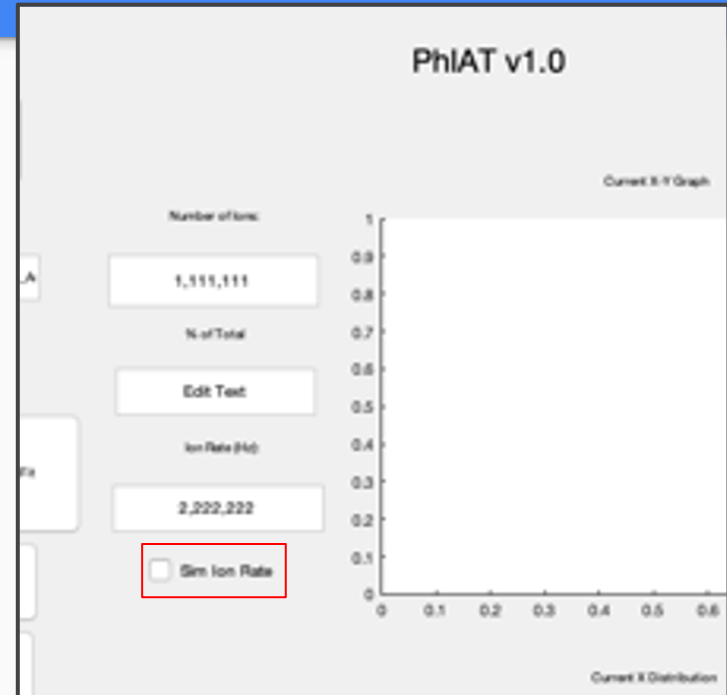
- The FileList.csv is used so PhIAT can navigate to each individual file and then load in that respective data

Automatic Filling

Directory of Midas Files (or FileList.csv)	~/path/to/files
Target File Location	~/path/to/store/saved/results/
Isotope	130Cs
Time in Trap	300ms
Date Taken	2016-07-21
Cyclotron Frequency Sweep (Hz)	114000.000000
Spot Angle (180° to 180°)	-30
Load List of Files	Automatic Fit

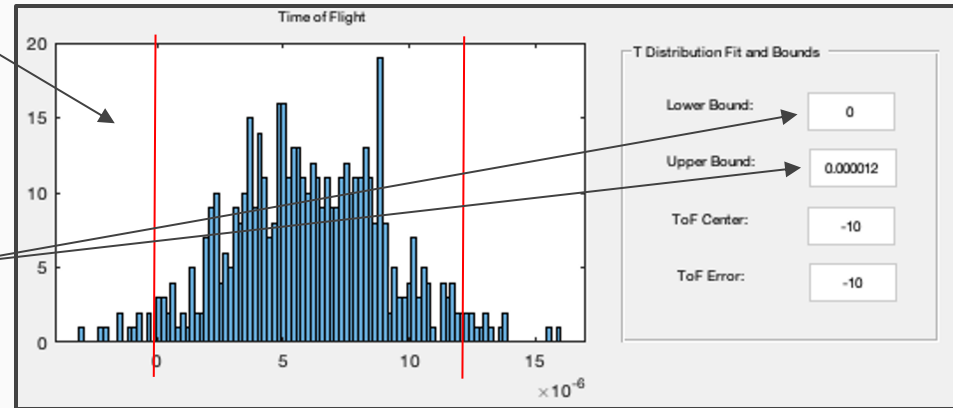
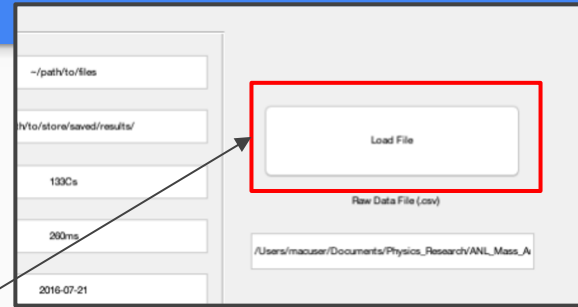
BEFORE YOU CONTINUE -- Simulated Data

- If you are fitting any simulated data (i.e. data produced from PI_ICR_simulated_data.m), **make sure the Sim Ion Rate checkbox is checked**
 - Since there is no count timing information from simulated data, leaving this unchecked will cause an error otherwise...



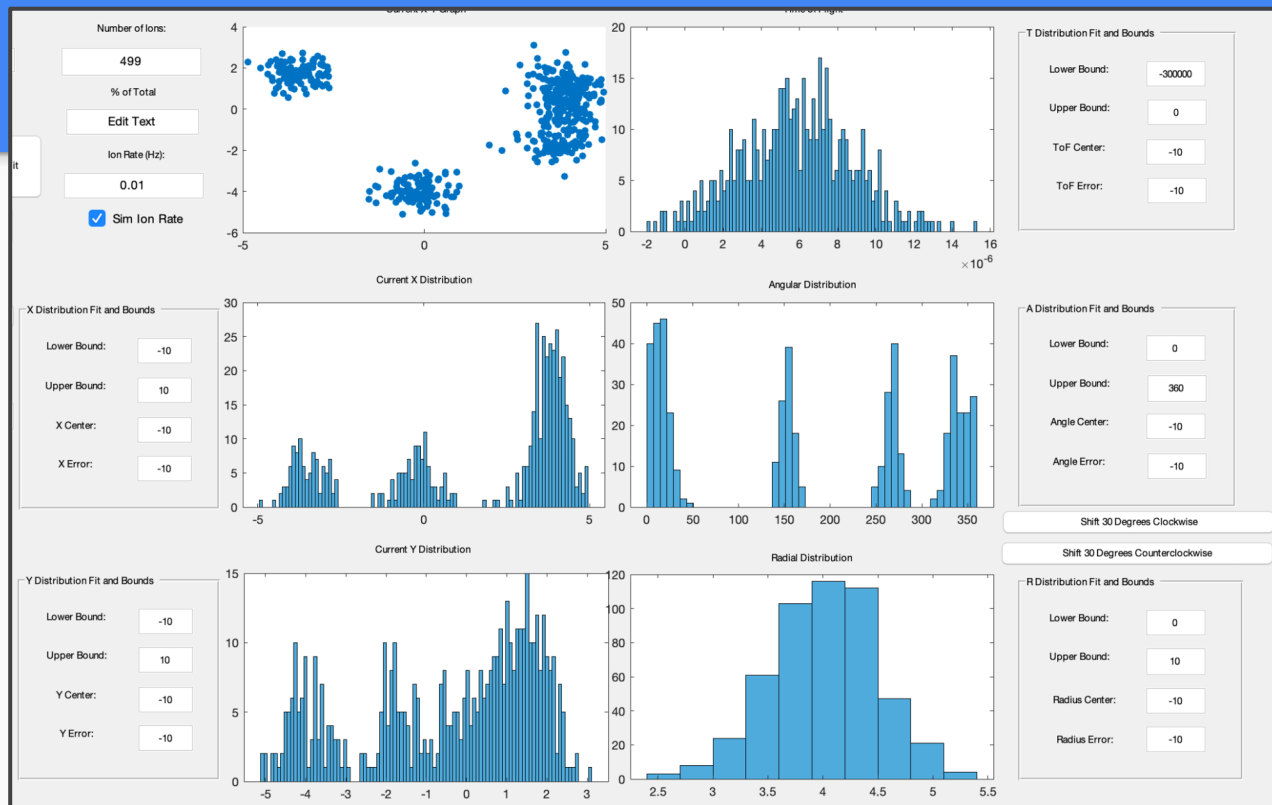
Fitting -- ToF Cuts

- It's advised to apply a time of flight cut to throw away data outside of the expected times of flight (i.e. column 3 of each data .csv)
- Press Load File to load just the first file
 - Using the distribution seen in the ToF plot, determine bounds that cut out data outside of the counts majority
 - It's expected the distribution is pseudo-Gaussian
 - Put these bounds in the Lower Bound and Upper Bound boxes next to the ToF plot



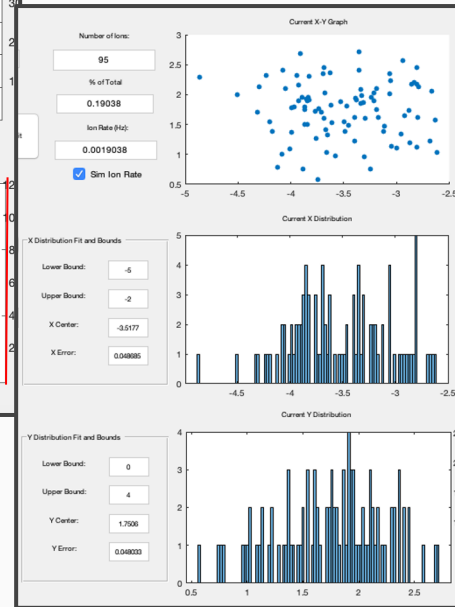
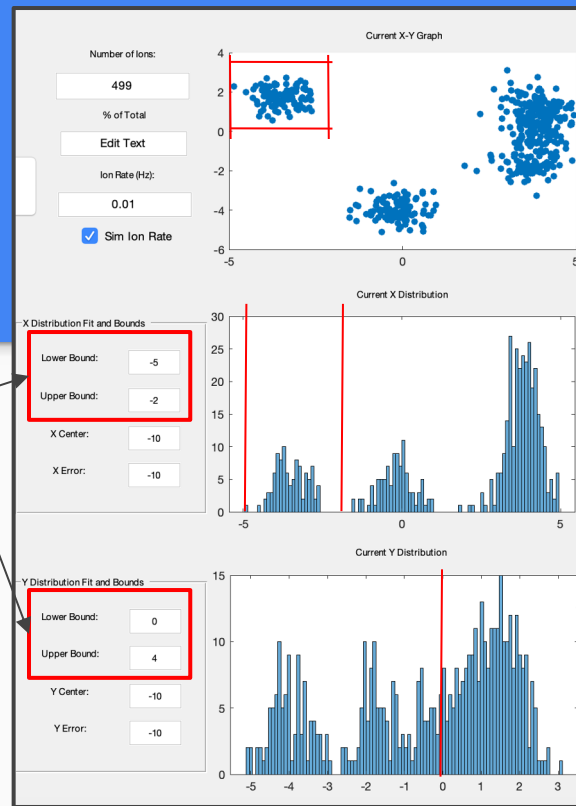
Fitting -- Other Cuts

- After pressing **Load File**, the data and relevant distribution will pop up:



Fitting -- Other Cuts

- To fit a spot, input X and Y gates in the respective lower and upper bound boxes to center around a spot
- Pressing **Recalculate Square Fit** will cut out all data outside these bounds
- This can also be done to cut out data using the Radial and Angular distributions
- NOTE: If at any point you make a mistake while manually gating, you can simply press Load File to restart



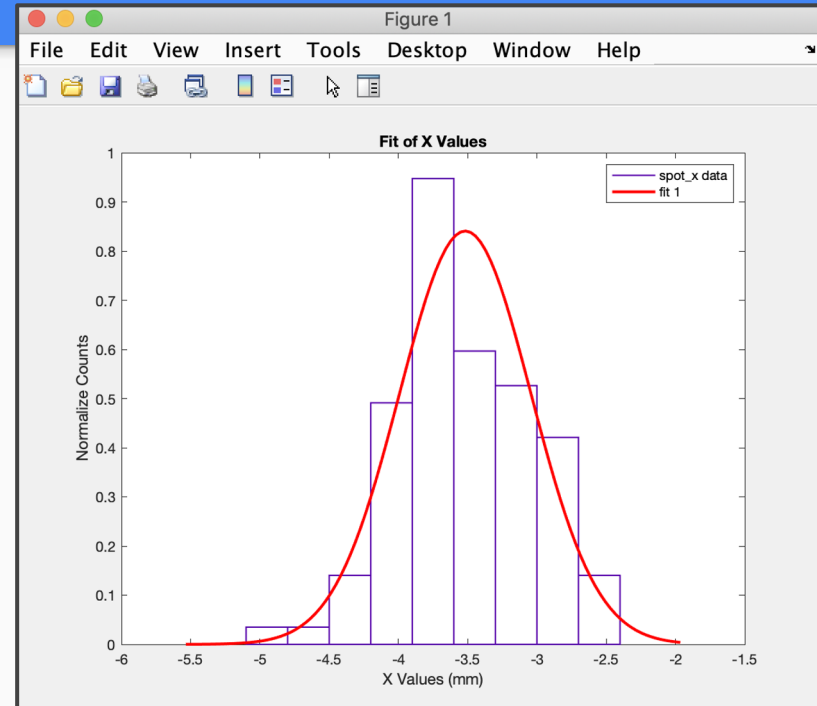
Fitting -- Recalculate Radial Fit

- Data can also be cut outside a radius of a specified point
- Choose X Center and Y Center to specify the point
 - Fit Radius: Data outside a radius of this value is cut away
- Pressing **Recalculate Radial Fit** does this cutting

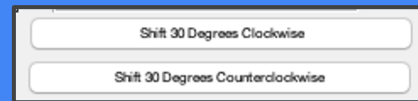
The screenshot shows a software interface for radial fitting. At the top, there are two buttons: "Recalculate Square Fit" and "Recalculate Radial Fit". The "Recalculate Radial Fit" button is highlighted with a blue border, and an arrow points from the text "Pressing **Recalculate Radial Fit** does this cutting" to it. Below these buttons are several other buttons: "Save Fits and Graphs", "Create Center Spot Redux CSV", "Save Angles and Radii", and "Finish Analysis". There are also two text input fields for file paths: "Center Spot Redux (.csv)" with the path "/Users/wspporter/Documents/Physics_Research/TITAI" and "Radius List (.csv)" with the path "/Users/macuser/Documents/Physics_Research/ANLJ". At the bottom, there is a section titled "Radial Fit and Bounds" which contains three input fields: "X Center" with the value "-1.5", "Y Center" with the value "3.0", and "Fit Radius" with the value "1.0". An arrow points from the text "Choose X Center and Y Center to specify the point" to the "X Center" and "Y Center" input fields.

Fitting -- Save Fits and Graphs

- Once satisfied with cuts applied, click **Save Fits and Graphs**
 - X, Y, Angular, Radial and ToF distributions are fit with a Gaussian using a Maximum Likelihood estimator to determine the spot center
- These five fits are printed out, and screenshots are saved in a folder labeled by the Tacc
 - This folder also contains other Excel files that are used by the script automatically later in analysis
- Upon press, the script automatically cycles to the next file in the FileList, so simply press **Load File** again to load in the next file and continue



Fitting -- Angular Cuts



- Since the distribution of angles will be fit, Shift 30 Degrees Clockwise or Counterclockwise can be selected to shift the angular data 30 degrees forward or backwards
 - This is so the distribution isn't cut off at 360 and can still be fit reasonably

Finish Analysis

- Once all files are fit (when 'No More Files Left' appears in the Raw Data File (.csv) box), press **Save Angles and Radii** and **Create Center Spot Redux CSV**
 - This creates a few more Excel files to be used by the code when finishing fitting
- In the text box beneath Center Spot Redux (.csv), input the address for the CenterSpotRedux.csv file created (in the directory you specified in Target File Location)
- In the text box beneath Radius List (.csv), input the address for the Radii.csv file created (in same directory as above)

Finish Analysis

- Press **Finish Analysis** and the script will automatically finish the rest of the analysis for you!
 - This is the same as is outlined in Automatic Fitting

- Please contact Sam Porter (wporter@triumf.ca) if you have any questions
- Happy PI-ICRing!