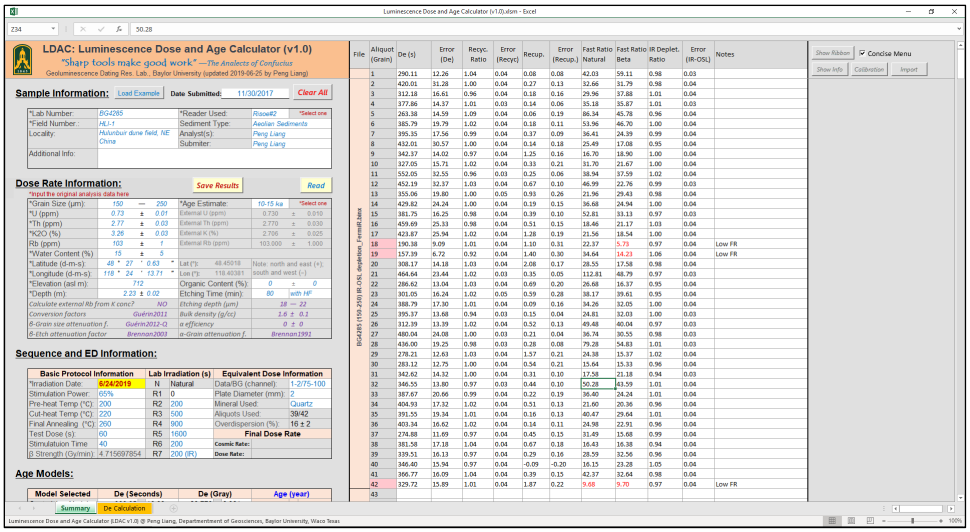
Luminescence Dose and Age Calculator (LDAC v1.0)

User Manual (12-28-2019)



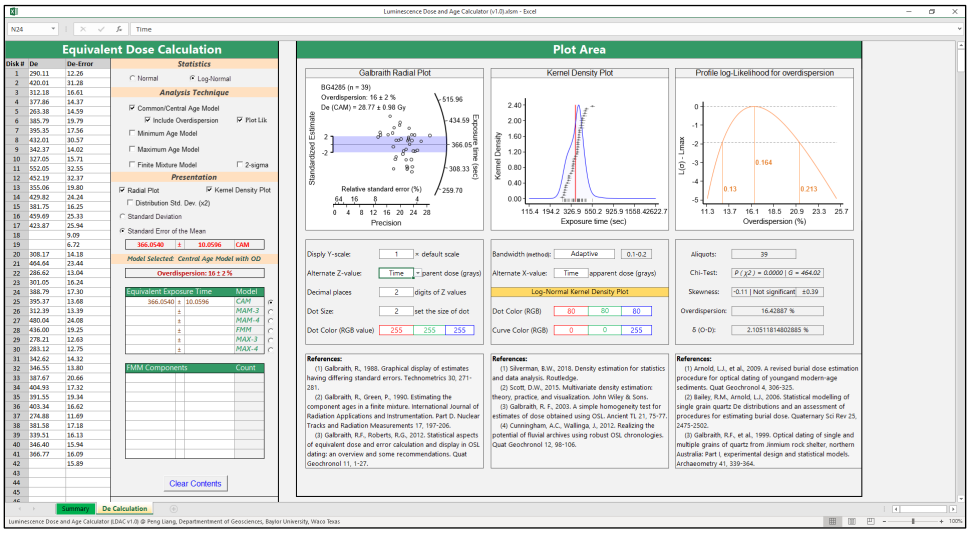


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Table of Contents

1. Introduction

- The Luminescence Dose and Age Calculator (LDAC) is a Microsoft Excel Visual Basic Application (VBA)-based package which can be used to assemble OSL age information and associated calculations. This platform applies statistical models to determine the equivalent dose (De) values and render corresponding OSL age estimates. This software is fully applicable for De measurements by single grain and aliquot regeneration (SAR) and thermal transfer OSL (TT-OSL) protocols. It could also be used to calculate the dose rate and final buried age for geology/archaeology samples. In general, this computational system is comprised of 14 linked functional computation routines worksheets. However, there are only two worksheets, i.e., "*Summary*" and "*De Calculation*", are visible when users open the workbook.
- **The protection password in LDAC is ";", which is used to protect the worksheet from unintentional modifications**.
- The logic and statistical bases for the LDAC can be found in the accompanying article: Liang, P., Forman, S.L., 2019. LDAC: An Excel-based program for luminescence equivalent dose and burial age calculations. Ancient TL 37 (2), 21-40.
- **Annotations**
  - *Physical worksheets (e.g., "Summary")*
  - Button (e.g., "Calibration")
  - Tag (e.g., "Reader Used")
  - *Software* (e.g., *Microsoft Excel*)
  - *Prompt message* (e.g., "*SECURITY WARNING Some active content has been disabled. Click for more details.*")
  - **Panel** (e.g., "**Sample Information**")

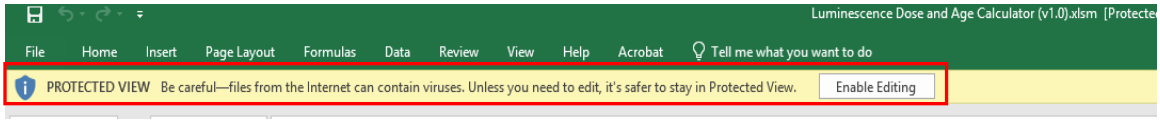
1.1 LDAC requirements

- LDAC requires *Microsoft Excel 2010* or higher version (e.g., *2013, 2016, 2019*) for *Windows* computers.
- *Macintosh Excel* can be used to preview the data, but the *Macros* cannot be run. A *Windows*-enabling program (e.g., *Fusion, Parallels*) is to run LDAC.

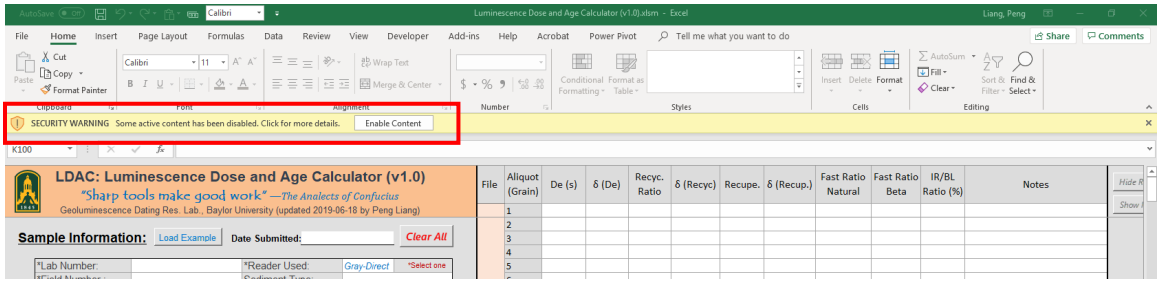
1.2 First running the LDAC

1.2.1 Enable running Macros

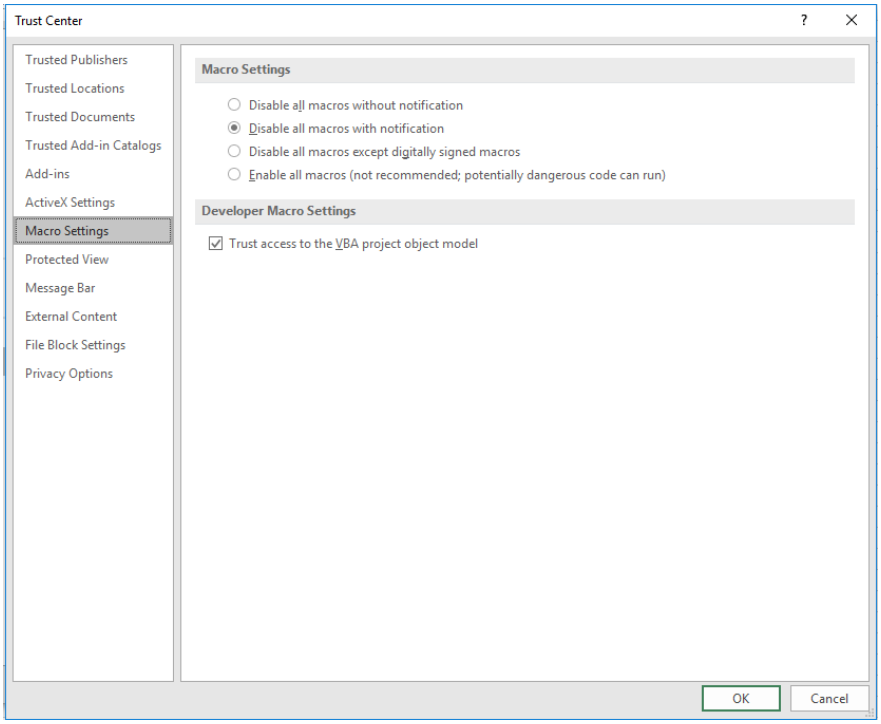
- Download the LDAC software from the website of Github (https://github.com/Peng-Liang/LDAC/releases) or the Geoluminescence Dating Research Lab, Baylor University (https://www.baylor.edu/geosciences/index.php?id=955927).
- Make sure the downloaded workbook's name is "LDAC (v1.0).xlsm". if not, rename it.
- Open the workbook just downloaded from the internet. A warning message will show "*PROTECTED VIEW Be careful-files from the internet can contain viruses. Unless you need to edit, it's safer to stay in Protected view*". Click "Enable Editing" to use this program.



- On first running, the program LDAC might appear the following message "*SECURITY WARNING Some active content has been disabled. Click for more details.*" This is a warning message for using *Macros* and command buttons (ActiveX controls) of the *Excel* workbook. Click "Enable Content".

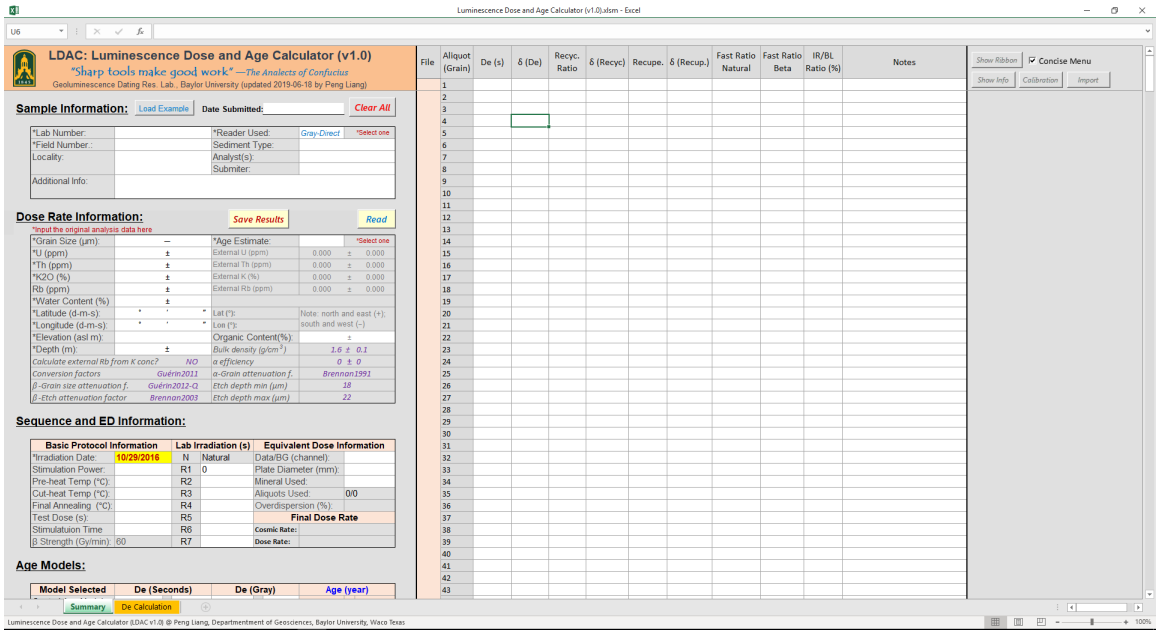


- If this warning message cannot be displayed and any button on the worksheet is not responding, check the macro settings in the Trust Center ("*Excel>File>Options>Trust Center>Trust Center Settings>Macro settings*") and set it as:



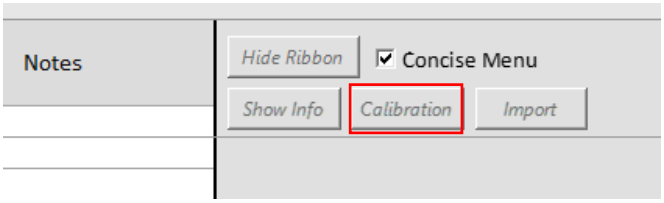
(Enabling or disabling Macros in Excel refer to support document from Microsoft website https://support.office.com/en-us/article/enable-or-disable-macros-in-office-files-12b036fd-d140-4e74-b45e-16fed1a7e5c6)

- Then, re-open the file.
- After enabling the active content, the "*Summary*" worksheet will appear, and all ribbons are hidden. The appearance of the main worksheet "*Summary*" when open a new LDAC is shown below.



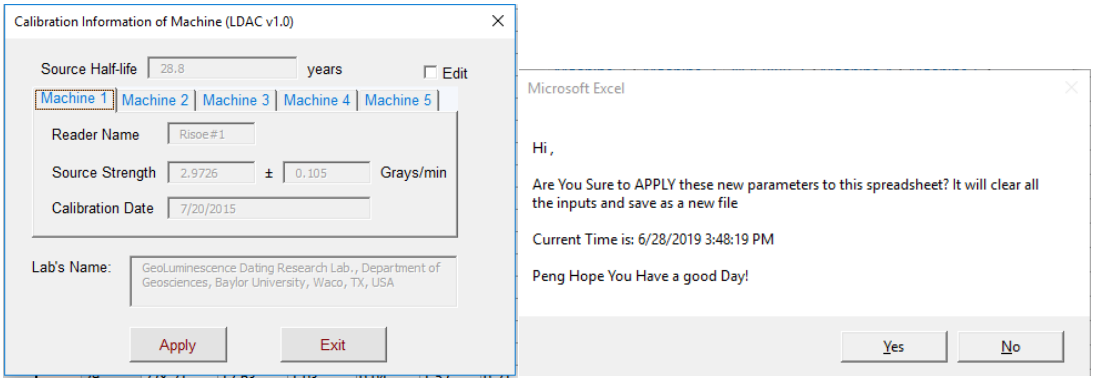
1.2.2 Source strength calibration

- On the upper-right corner in the "*Summary*" page, there are 4 buttons that activate (or deactivate) different actions. In the center of the second line, a button named "Calibration" is found.



- By clicking the "Calibration" button, a window named "Calibration information of Machine (LDAC v1.0)" will appear. This window shows the source strength information of ***Risø TL/OSL*** readers. Users can tick the "Edit" option to enter the new information for their laboratory.

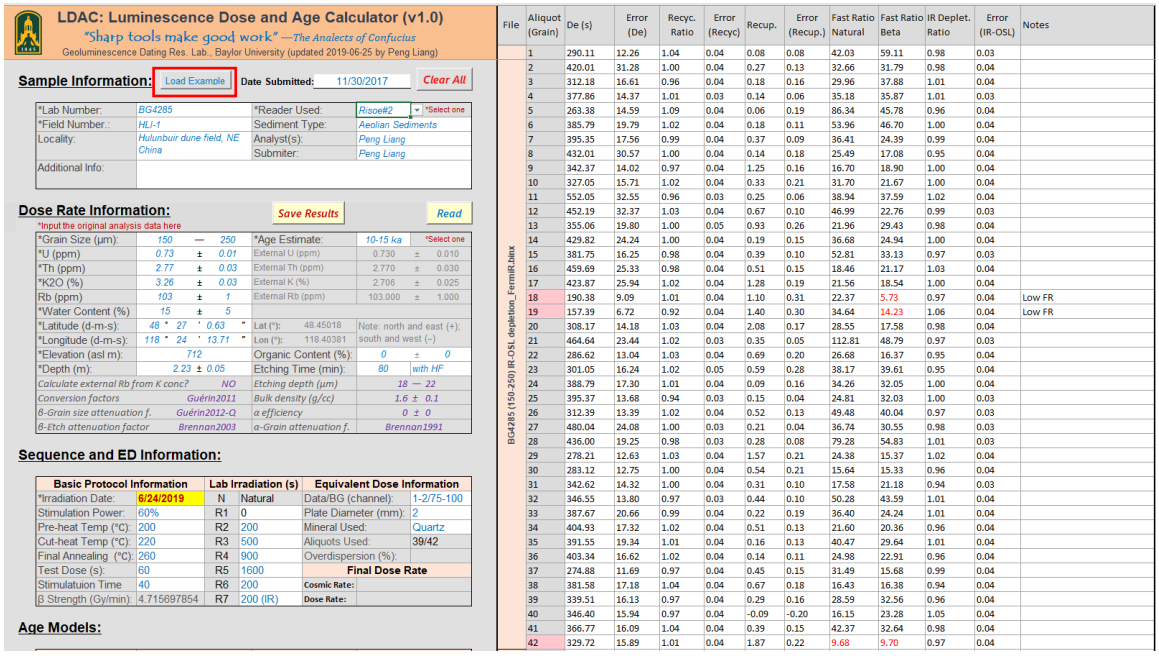
- Note that the input reader names in this dialog box will appear in the list of the "Reader Used" cell on the "**Sample information**" panel in the "*Summary*" page (see section 2.1). The source strength of the reader will be used in the subsequent conversion between laboratory dose in "seconds" and irradiation unit in "Grays".



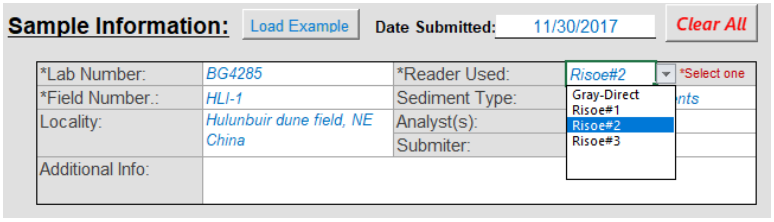
- The "Lab's Name" is an optional input but is recommended since it will appear in the "*.pdf" version of the final laboratory report. Click the "Apply" button to save the information in LDAC after inputting all calibration information in this dialog box.
- After entering the password (";"), a message box will be popped up showing "*Are you sure to APPLY these new parameters to this spreadsheet? It will clear all the inputs and save as a new file*" to confirm any calibration changes. Click "Yes" to continue, click "No" to exit without saving.

2. Data entry

- All grey cells in LDAC are locked and protected, and the value cannot be modified.
- Users are recommended to click the "Load Example" button to get familiar with the data format and usage of LDAC prior to input their information for the first time. Fields marked with an asterisk (*) (e.g., *Lab Number, *Reader Used) are required because they will affect subsequent calculations or final report.



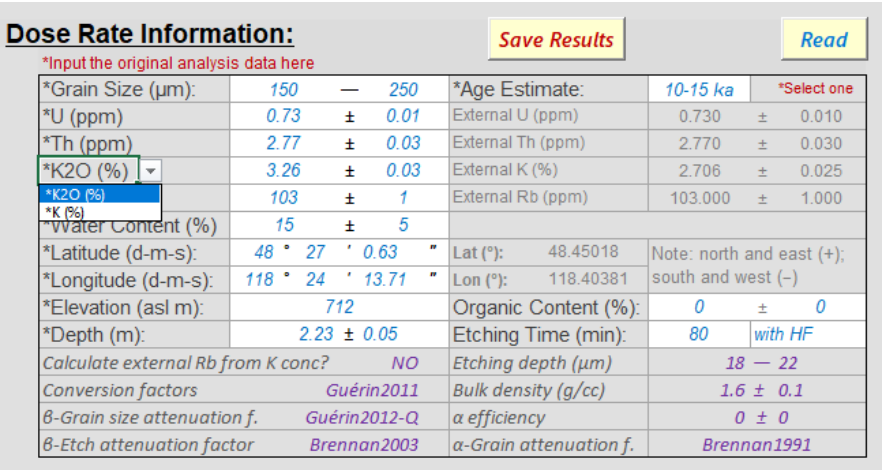
2.1 Sample Information



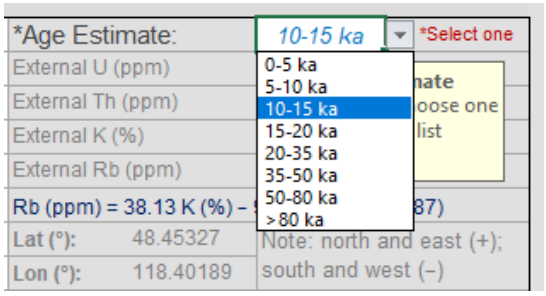
- The "Lab Number" will be used to name the file and must correspond with the lab number given to the sample during lab preparation and measurement.
- The lists of "Reader Used" are from the "Calibration" (see section 1.2.2). If the dose values imported from the *"Analyst"* program have been converted to Grays (users have input the source dose rate in *"Sequence Editor"*), please select "Gray-Direct".

2.2 Dose Rate Information

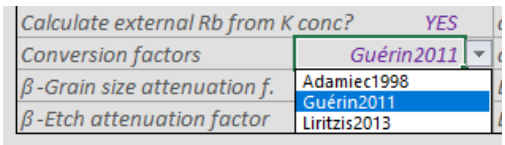
2.2.1 Necessary dose rate information (for external dose rate)



- The "Grain Size" used in the analysis, along with the content of U and Th in ppm must be input for each sample.
- The potassium content can be input as either K (%) or K_2O (%) via selecting from the list. If the input is K_2O, it will be converted to K (%) in the right hand of the input area.
- The "Water Content" must be input from the information gathered in the laboratory or derived from the user.
- The "Age Estimate" is used to correct the geomagnetic field variations through time, hence the cosmic dose rate. A drop-down list (see below) is offered to select an approximate age range.



- The geographic coordinates can be input in either "d-m-s" or "degree" format. If you need to input in degree format, just input the number before "°". North and east are positive values, while south and west are negative values. The projected coordinates (e.g., UTM, in linear unit) should be converted to a geographic coordinate system.
- All purple values in the "**Dose Rate Information**" panel can be modified. Users can select or input their preferred parameters or values.



- If users need to calculate external Rb from K content (select "Yes"), this conversion will be done based on an empirical equation: Rb (ppm) = 38.13 K (%) − 9.17 (Mejdahl, 1987). Thus, this Rb content will be used in the subsequent dose rate calculation.

2.2.2 Optional input for internal dose rate calculation

Optional Input for Dose Rate Calculating

Internal Radionuclide Concentrations				User external Dα (mGy/yr)			
Internal U (ppm)		±		User external Dβ (mGy/yr)		±	
Internal Th (ppm)		±		User external Dγ (mGy/yr)		±	
Internal K (%)		±		User defined Dc (mGy/yr)		±	
Internal Rb (ppm)		±		User internal Dr (mGy/yr)		±	

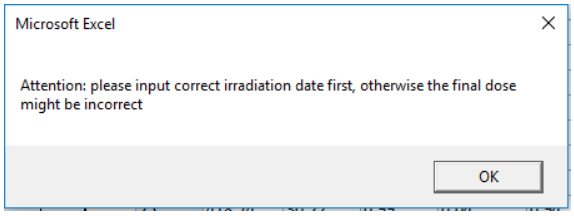
- If the internal dose rate of the mineral grain is needed to be incorporated in the dose rate calculation (such as for K-feldspar), users can input the associated values in the "**Optional input for Dose Rate Calculation**" panel, at the bottom of the "*Summary*" page.
- In the same manner, this panel allows for inputs of the user-specified dose rate values for subsequent attenuation and calculation.

2.3 Sequence and ED information

Sequence and ED Information:

Basic Protocol Information		Lab Irradiation (s)		Equivalent Dose Information	
*Irradiation Date:	6/24/2019	N	Natural	Data/BG (channel):	1-2/75-100
Stimulation Power:	60%	R1	0	Plate Diameter (mm):	2
Pre-heat Temp (°C):	200	R2	200	Mineral Used:	Quartz
Cut-heat Temp (°C):	220	R3	500	Aliquots Used:	0/42
Final Annealing (°C):	260	R4	900	Overdispersion (%):	
Test Dose (s):	60	R5	1600	Final Dose Rate	
Stimulatuion Time	40	R6	200	Cosmic Rate:	
β Strength (Gy/min):	4.715697854	R7	200 (IR)	Dose Rate:	

- The "Irradiation Date" is important if the De values are imported in "seconds". If the default value is not changed when you click the "Read" button to transfer the data from the "*Summary*" page to "*De Calculation*" page, a message will automatically pop up, prompting you to enter the date of the radiation.

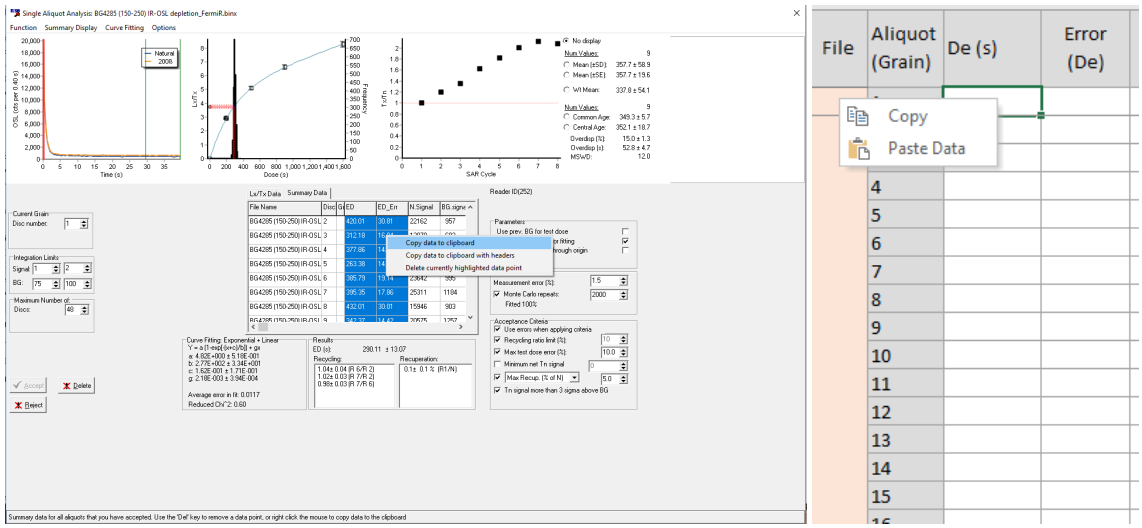


- The "Irradiation Date" can be entered manually following the date format or double click the data entry cell to pick up a date from the pop-up calendar.

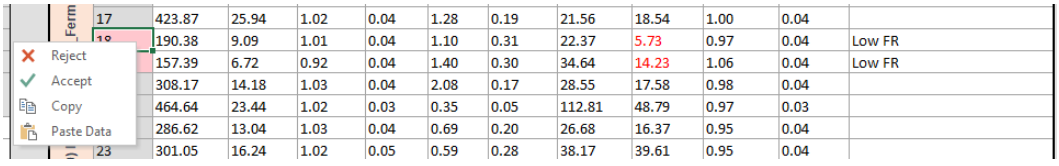
2.4 Data entry for equivalent doses

File	Aliquot (Grain)	De (s)	Error (De)	Recyc. Ratio	Error (Recyc)	Recup.	Error (Recup.)	Fast Ratio Natural	Fast Ratio Beta	IR Deplet. Ratio	Error (IR-OSL)	Notes
	1											
	2											
	3											
	4											
	5											
	6											
	7											
	8											
	9											

- The data entry for De values and pertinent diagnostic metrics can be conveniently imported from the *"Analyst"*. Users can copy data to clipboard from the *"Analyst"* and right click in LDAC to paste it.

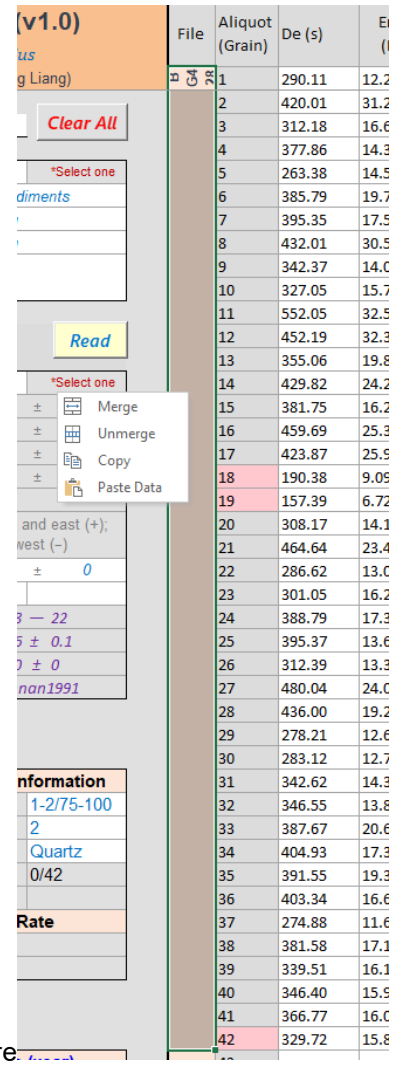


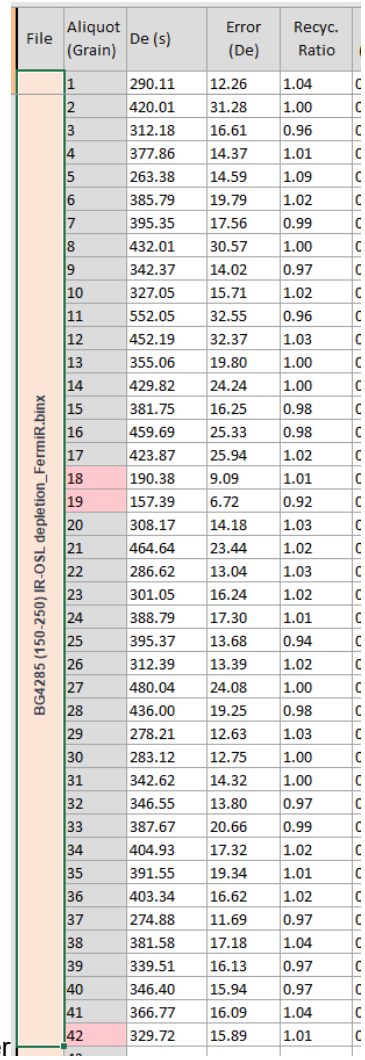
- The values will be automatically marked with red color when: the relative error of De values >10%, De values plus the error <0, the recycling ratio limits >10%, the percentage recuperation >5%, the fast ratio >15%, the IR depletion ratio limits >10%.
- Users can right-click on the aliquot/grain number column to manually "Reject" the aliquots or grains which fail to pass the criteria, and the cell of rejected aliquots will be filled with reddish-pink.
- If for any reasons, data need to be reconsidered for analysis, users can click "Accept", the cell color will turn grey again.



	17	423.87	25.94	1.02	0.04	1.28	0.19	21.56	18.54	1.00	0.04	
	18	190.38	9.09	1.01	0.04	1.10	0.31	22.37	5.73	0.97	0.04	Low FR
	19	157.39	6.72	0.92	0.04	1.40	0.30	34.64	14.23	1.06	0.04	Low FR
	20	308.17	14.18	1.03	0.04	2.08	0.17	28.55	17.58	0.98	0.04	
	21	464.64	23.44	1.02	0.03	0.35	0.05	112.81	48.79	0.97	0.03	
	22	286.62	13.04	1.03	0.04	0.69	0.20	26.68	16.37	0.95	0.04	
	23	301.05	16.24	1.02	0.05	0.59	0.28	38.17	39.61	0.95	0.04	

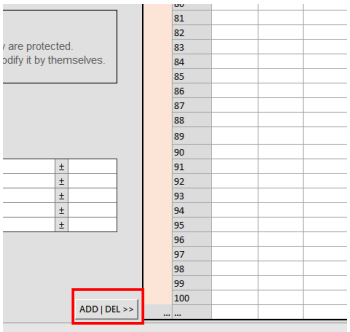
- Users can select several cells in the "File" column and right-click to "Merge" (or "Unmerge") and input a corresponding "*.binx" file name of the De values came from. It can be used to trace the raw data from the luminescence reader.
- For the example data, the following case demonstrates that the De values for Aliquots 1-42 are from the file "*BG4285 (150-250) IR-OSL depletion_FermiR.binx*".

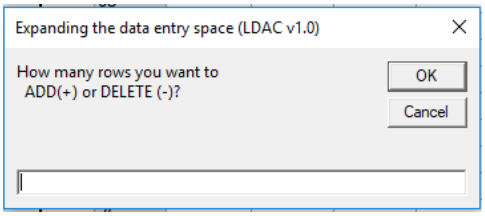
Before 

, after 

2.5 Expand the data entry spaces

- By default, LDAC has 100 data entry rows for inputting De values. However, users can easily expand it up to 5,000 rows by clicking the button "ADD | DEL >>" at the bottom of the "*Summary*" page. Pressing the "ADD | DEL >>" button will pop up a dialog box "Expanding the data entry space (LDAC v1.0)".
- Users can input a positive number (+) to add rows and a negative number (-) to delete rows.

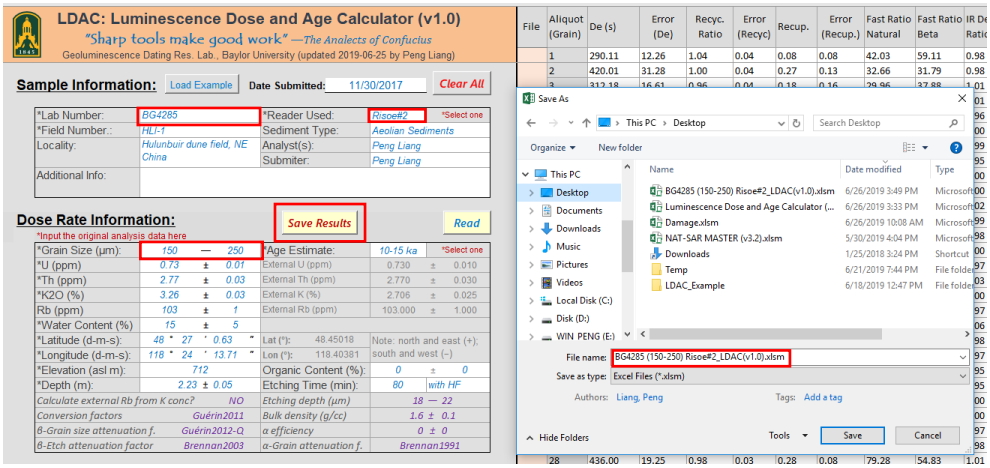




3. Save Results

Note: Always remember to save your inputs and results.

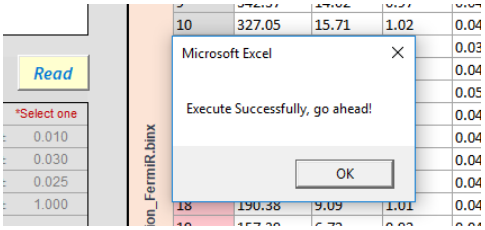
- The LDAC hide the Ribbons of the original *Microsoft Excel*, which aims to protect the program from being unintentionally modified. User can press the button Save Results to save the files at any time.
- The file will be automatically named based on the input values of "Lab Number", "Grain Size" and "Reader Used", and the version of LDAC.
- For example, we have a sample and the input information as below: the lab number is "BG4285"; the reader used is "Risoe#2"; the grain size range is "150-250"; the program version is "LDAC (v1.0)".
- By clicking the button Save Results, a "save as" dialog box will be popped up, and the file name "*BG4285 (150-250) Risoe#2_LDAC(v1.0).xlsm*" has been automatically generated. Users just need to select an appropriate save path. The file name can be changed manually if desired.

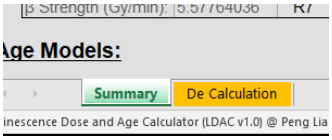


- Every time you save the results, the cells below the "Comments" panel will show and update a message, i.e. "*Report finished at 6/28/2019 11:46:39 AM by Liang, Peng*", which will automatically store the date, time and analyst of the last saving.

4. Transfer data to the "De Calculation" page for further analyses

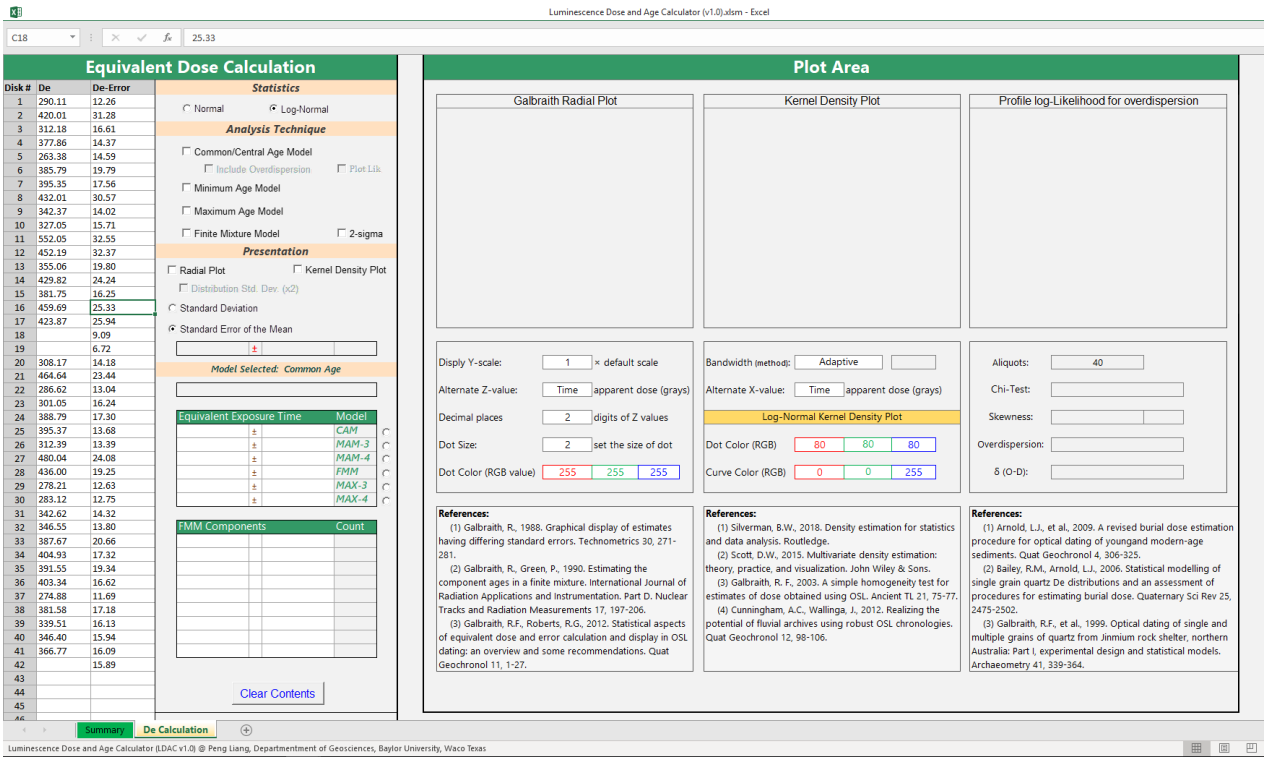
- Pushing the "Read" button transfers the accepted De values and associated errors (not marked as reddish-pink) to the "*De Calculation*" page of LDAC. This data is used for subsequent calculations, such as applying statistical age models. The data that failed to pass the criteria will not be transferred. Once the data transfer process finished, a prompt message "*Execute successfully, go ahead!*" will pop up. Click "OK" to continue.
- Click the worksheet name "*De Calculation*" in the bottom of the workbook to go to this page.





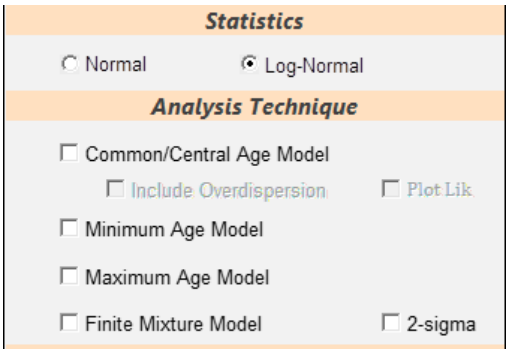
5. Apply statistical models

- The statistical analyses of the equivalent dose data set are performed on the "*De Calculation*" worksheet.
- The data that failed to pass the criteria will not be transferred to this page, but all errors will show here. Only the data passed quality control will participate in the subsequent calculation and data visualization. For example, there are 42 measured aliquots in the example data (see figure below), but the aliquot 18, 19 and 42 failed to pass the quality control. In this case, these aliquots are excluded from the subsequent analyses.



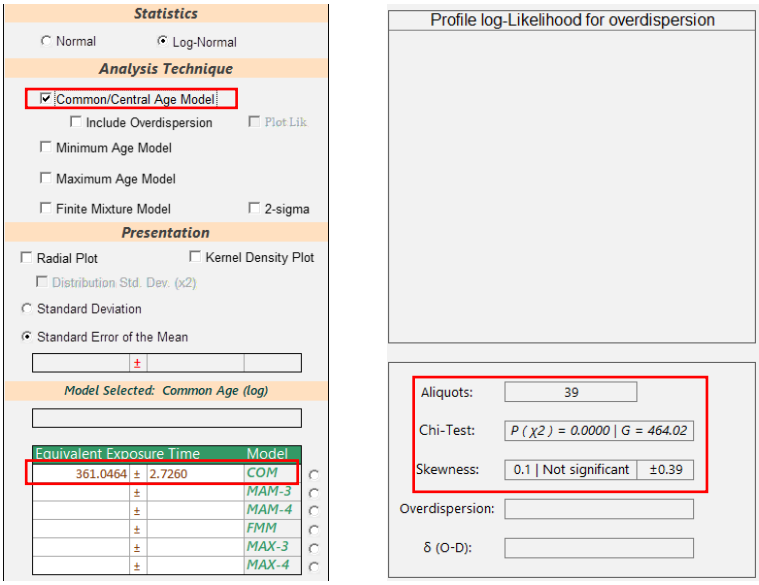
5.1 Analysis technique

- There are five age models in LDAC, including Common, Central, Minimum, Maximum, Finite mixture age models.
- Except for Maximum age model, all models can be applied to both normal or log-normal scale via selecting the option button "Normal" or "Log-Normal" at the top of the page.



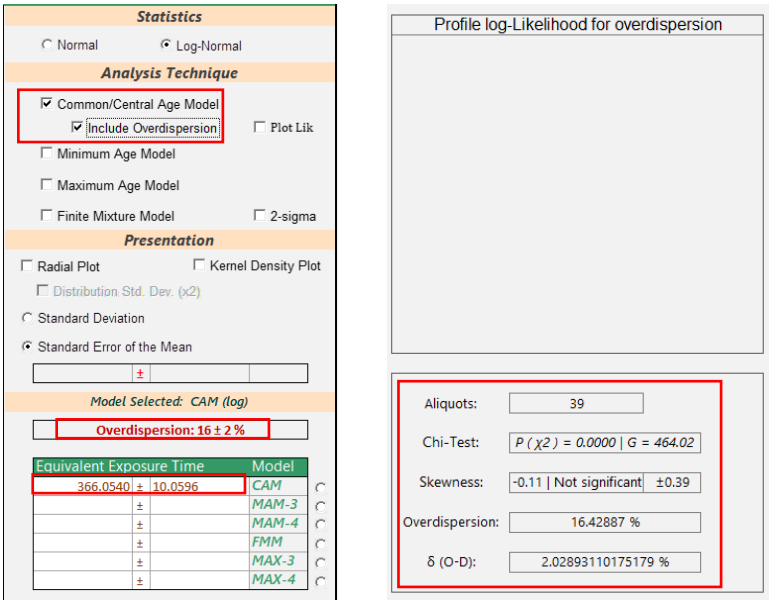
5.1.1 Common Age Model and Statistical parameters

- Engage the checkbox "Common/Central Age Model" to apply this model to the data.
- There is a prompt message showing "*Model selected: Common Age (log)*". The age is calculated and show on the "**Equivalent Exposure Time**" panel and labeled as "COM".
- At the same time, the panel below the "**Profile Log-Likelihood for overdispersion**" plot area, to the right, shows the valid aliquots number, Chi-square test and weighted skewness of the data.

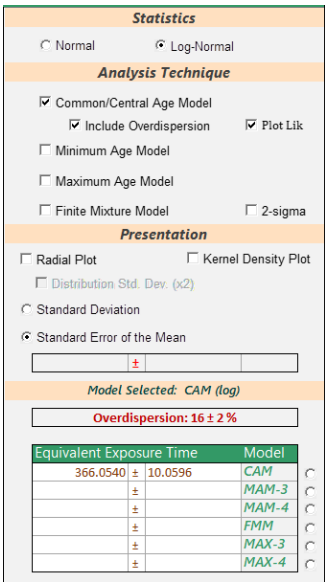


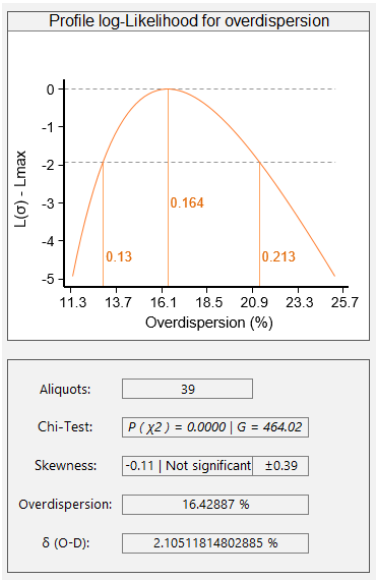
5.1.2 Central Age model (CAM) and overdispersion

- When the checkbox "Common/Central Age Model" is ticked, the grey checkbox "Include Overdispersion" will be enabled.
- Engage the checkbox "Include Overdispersion" to apply the CAM. Applying the CAM will recalculate the weighted skewness (e.g., from 0.1 of the above figures to -0.11of the below figures).

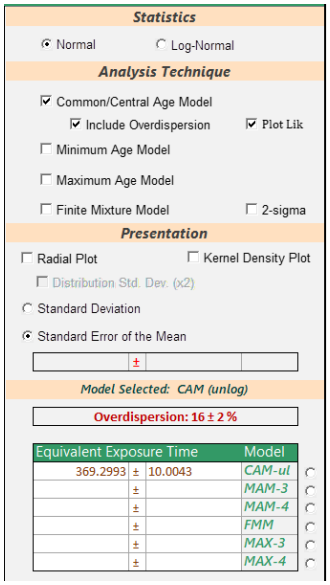


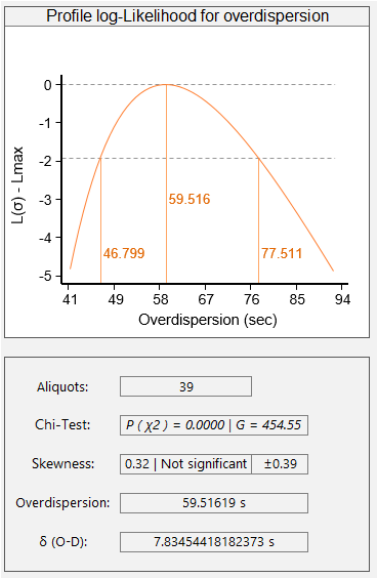
- An overdispersion value will also be computed after applying the CAM. This overdispersion will be rounded to whole percentage number and show on the left panel. The prompt message will show "*Model Selected: CAM (log)*", and the model name is labeled "CAM".
- When the checkbox "Include Overdispersion" is true, the grey checkbox "Plot-Lik" will be enabled. This checkbox is used to construct the "profile log-likelihood function" and re-estimate the standard error of the overdispersion value.





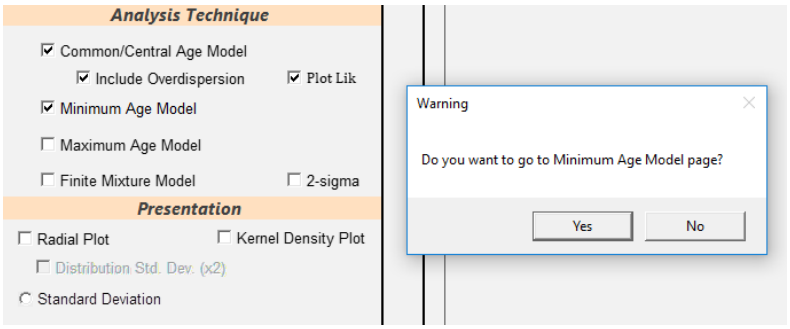
- If you chose the "Normal" at the top and then apply the CAM and engage the "Plot Lik" checkbox, the "**Profile log-likelihood for overdispersion**" will show the overdispersion and 95% compatibility interval in "seconds" instead of in "%".
- This value will be converted to relative overdispersion (in %) to show in the left panel. The model name is labeled as "CAM-ul".



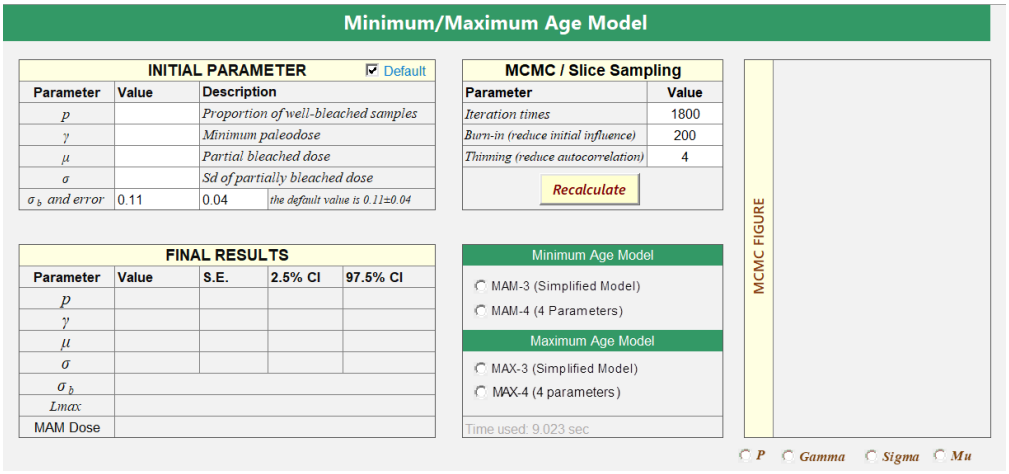


5.1.3 Minimum Age Model (MAM)

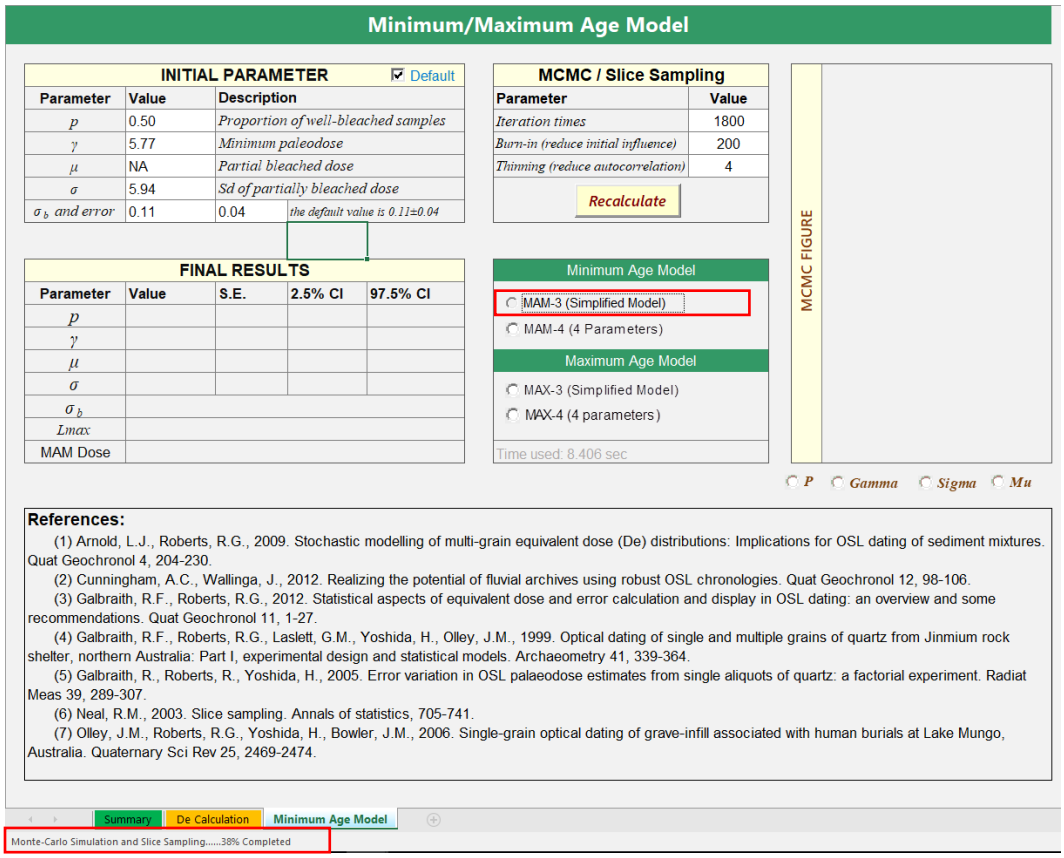
- After ticking the checkbox "Minimum Age Model", a dialog box showing "*Do you want to go to Minimum Age Model page?*" will be popped up.
- Click "Yes" if you want to apply the minimum age model analysis, click "No" if not.



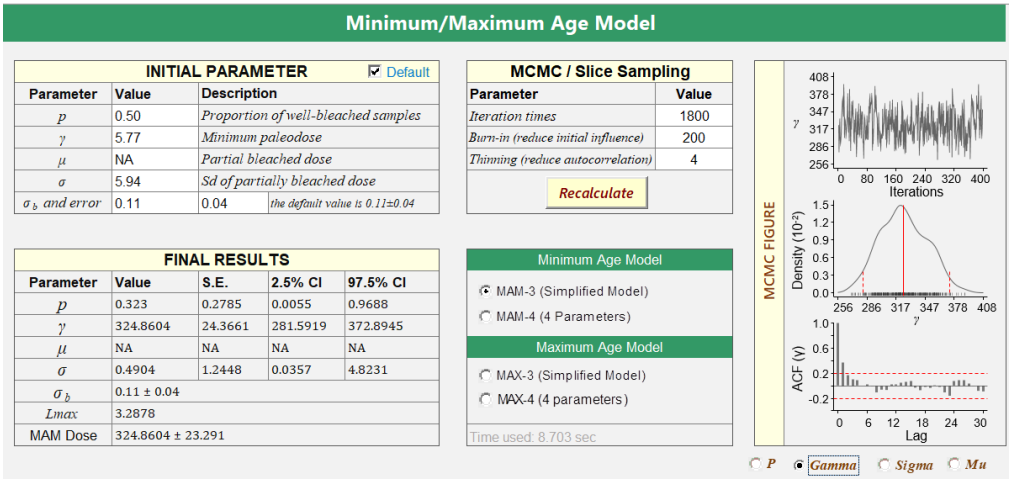
- If you click "Yes", a new worksheet entitled "*MAM-MAX*" will be activated.



- Users just need to input appropriate σ_b and error values. The default value 0.11±0.04 can also be used.
- If the checkbox "Default" on the "**Initial Parameter**" panel is ticked, the p, γ, μ and σ are not needed to input. The LDAC will calculate these initial values based on the valid data in the "*De Calculation*" page.
- Click MAM-3 (Simplified Model) or MAM-4 (4 Parameters) to execute the corresponding age models. MAM-3 will work with three parameters (p, γ, σ), while the MAM-4 will use four parameters (p, γ, μ, σ).
- By default, a total of 1800 iterations of Markov chain Monte Carlo (MCMC) slice sampling will be implemented. The first 200 iterations of the MCMC will be discarded ('burn-in') and apply a data thinning routine of registering every 4th value to avoid autocorrelation.
- The Iteration times, burn-in, and thinning can be modified in the "**MCMC / Slice Sampling**" panel to satisfy the needs of each project.

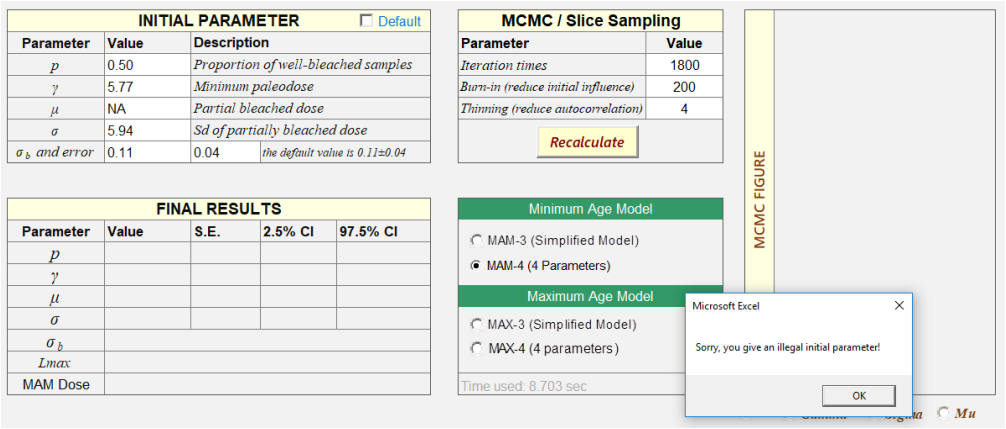


- After clicking the "MAM-3 (Simplified Model)", the Monte Carlo slice sampling will be executed based on the input iteration times.
- Due to this process is time-consuming (commonly 3-30 s, depends on the sample size and computer performance), a prompt message is displayed on the bottom of the workbook to show the progress such as "*Monte-Carlo Simulation and Slice Sampling.....38% Completed*" (see above figure).
- After it finished, the main outputs will show on the "**Final Results**" panel. Users can click the option buttons on the right-bottom to show the MCMC results as graphs and judge the convergence states based on the trace plots, marginal densities and Autocorrelation functions (ACF).

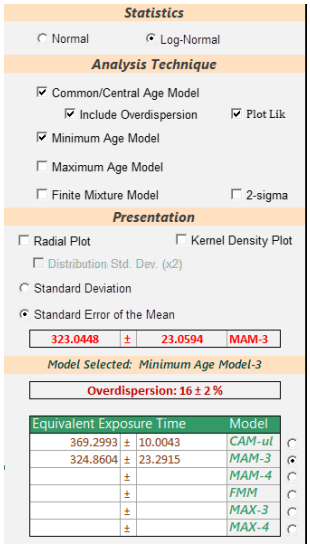


- Users can modify the initial parameters by unchecking the "Default" and inputting their own values in the input cells. The "Recalculate" button is used to clear the existed results and re-run the models.
- The p is the proportion of well-bleached grains, so p should be in range 0-1; the γ denotes the lower truncation point and corresponds to the supposed youngest population, so γ should be greater than the minimum value of the data set, and less than the maximum value of the data set; the μ has the same range as γ.
- If these values are out of the supposed ranges, a message will be popped up to show "*Sorry, you give an illegal parameter*" and exit the model.
- The following case shows that a warning message is popped up when we want to run the MAM-4 because one of the initial parameters μ is not a numeric value.

The default values are recommended if you are not sure what initial parameters should be given.



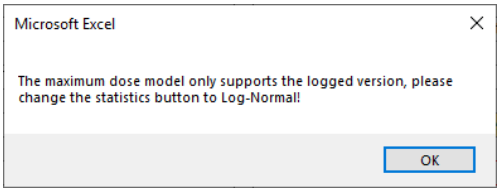
- If you get appropriate MAM results, you can go back to the "*De Calculation*" page via clicking the worksheet name "*De Calculation*" on the bottom of the workbook.
- The final result of the MAM has been automatically transferred to the "De Calculation" page and is labeled as "MAM-3" (if "Normal" is ticked, it should be "MAM-3ul").



- Similarly, if "MAM-4 (4 Parameters)" function is executed, the result will show here as "MAM-4".

5.1.4 Maximum Age Model (MAX)

- The operation of MAX is the same as the MAM. It is paramount to remember that the MAX can only be executed to log-transformed data.
- Thus, make sure to tick the "Log-Normal" on the top before using the MAX. Otherwise, the message box showing "*The Maximum Age Model only supports the log-transformed data, please change the statistics button to 'Log-Normal'*!" will be popped up.

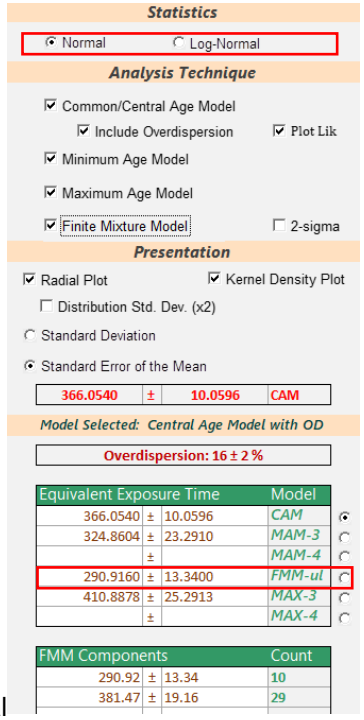


- Tick the "MAX-3 (Simplified model)" or "MAX-4 (4-Parameters)" in the "**Maximum Age Model**" panel on the "*MAM-MAX*" page to execute the MAX. As with the MAM, the final result will be automatically transferred to the "*De Calculation*" page and is labeled as "MAX-3" or "MAX-4". The parameters are the same as the MAM.

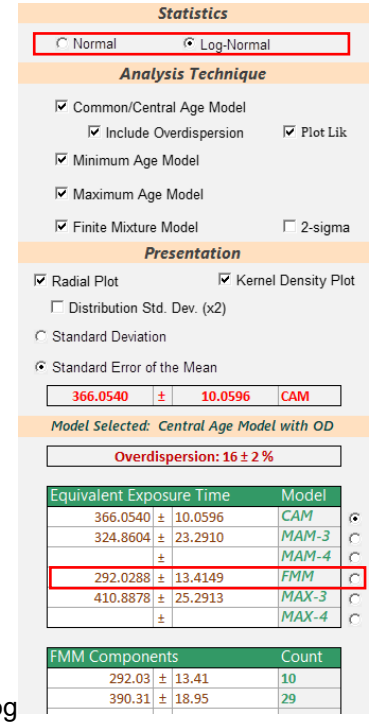
5.1.5 Finite Mixture Model (FMM)

- Tick the "Finite Mixture Model" checkbox to apply the FMM to the data. The results will show in the "**FMM components**" panel. All FMM components and corresponding absolute proportion will be listed. The youngest component which proportion >10% will be automatically picked up to the "**Equivalent Exposure Time**" panel and is labeled as "FMM" or "FMM-ul" for Log-Normal or Normal statistics, respectively. Depending on the characteristics of the target sample, users can also manually pick up a preferred component.

FMM-Normal



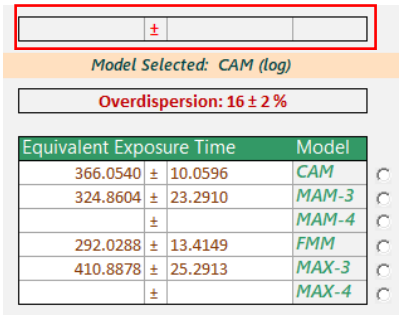
FMM-Log



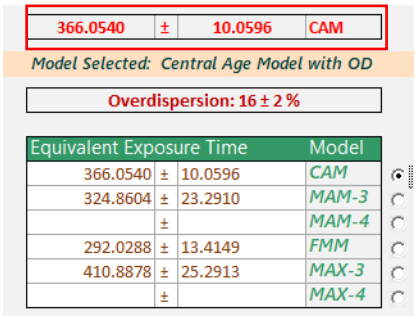
5.1.6 Transfer the selected result to the "Summary" page

- After all statistical analysis has been performed on the data using the "*De Calculation*" page, users must pick a value via the corresponding option button. This action delivers the final De value to the "*Summary*" page for final age calculation. The following figures show an example, where the CAM result is chosen as the final De value to be transferred for final age calculation via clicking the options button after CAM.

Before selected:

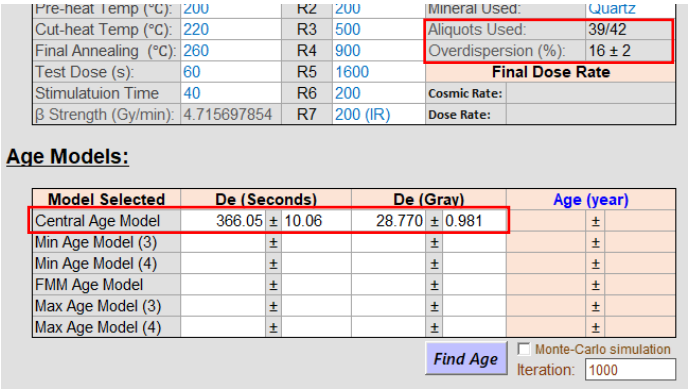


After selected:

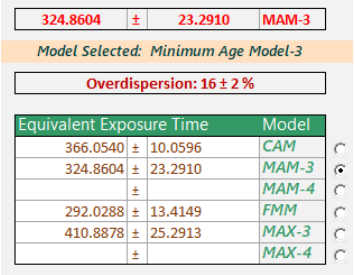


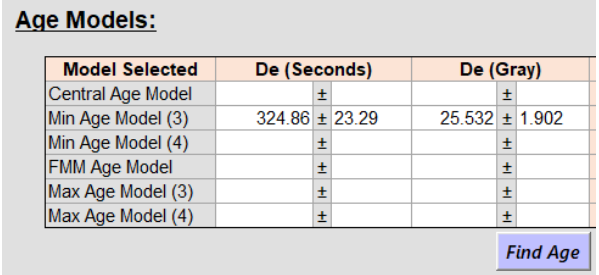
- The corresponding value and error will be delivered automatically to the above final result cell as red color. This value will also appear in the respective **Age Models** cell in the "*Summary*" page. The overdispersion value and the number of aliquots used will be transferred to the "*Summary*" page in the "**Sequence and ED Information**" panel.

- The "De (Seconds)" shows the values derived from the original data while the "De (Gray)" shows the value converted from second to grays based on the source strength (See section 1.2.2). For example, 366.05 (s) /60 (s/min) * 4.715697854 (Gy/min) =28.77 (Gy). The error is propagated in quadrature.



- If we chose the result from MAM-3, the value will be transferred to corresponding cells.

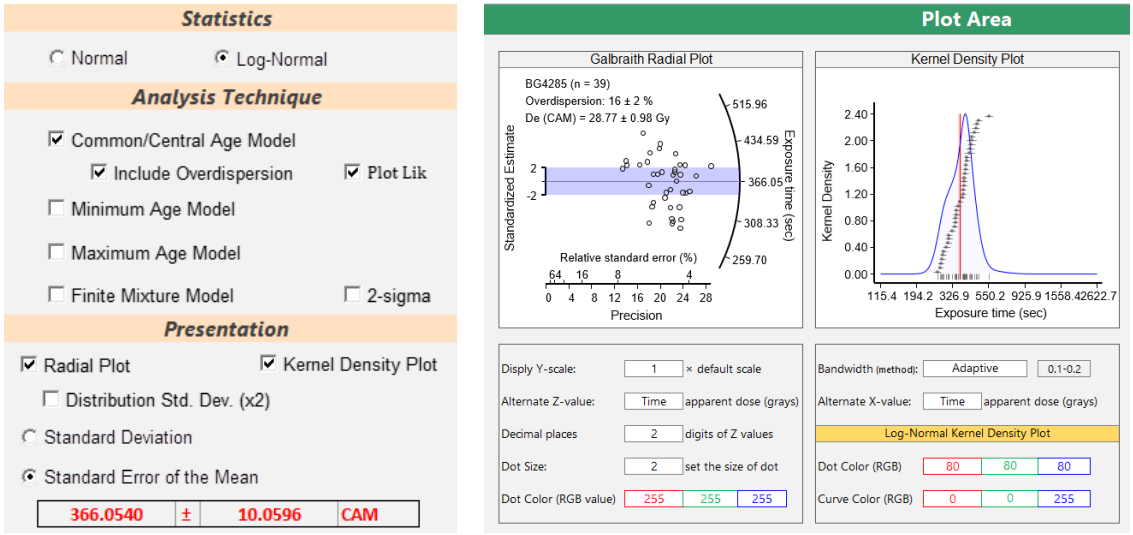




- This chosen value can also be as a reference value to visualization the data and it can be plotted in radial plot or kernel density plot (see section 5.2).

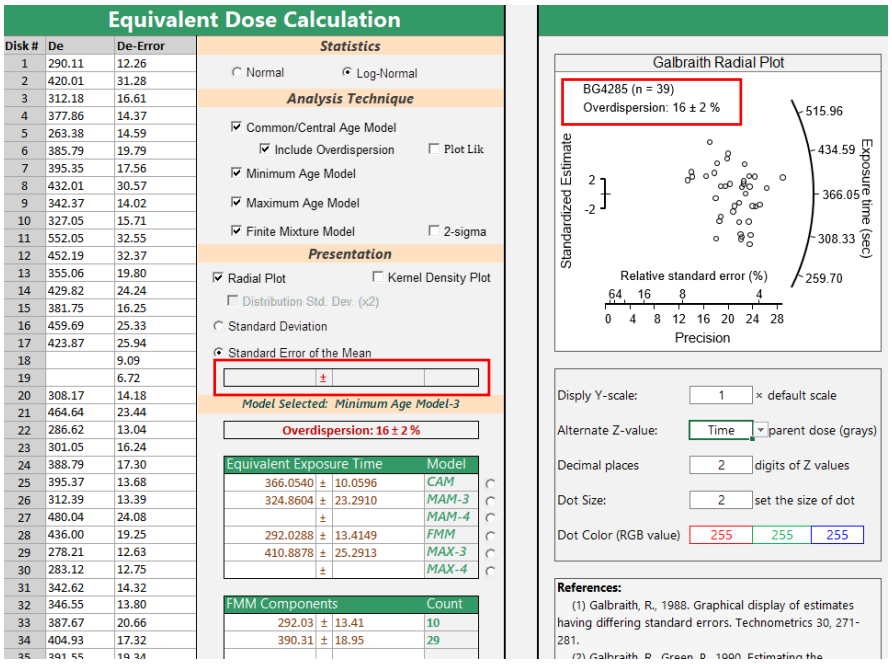
5.2 Graphical Presentation

- The graphical presentation for data is performed via ticking the "Radial Plot" and "Kernel Density Plot" checkbox in the **"Presentation"** panel.



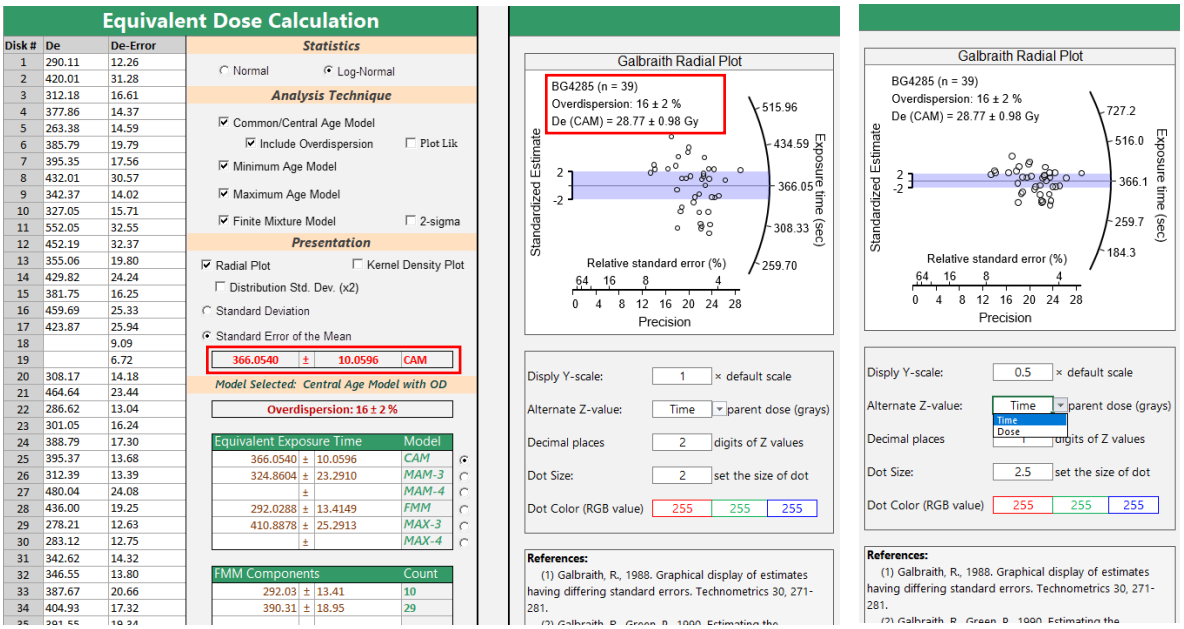
5.2.1 Radial Plot

- If the final result cells are empty, the radial plot can be created via ticking the "Radial Plot" checkbox but no reference value (the band of standardized estimate) (see the figure below).
- The radial plot marks the sample information, i.e., lab number, valid aliquots, overdispersion value on the left-top of the plot.

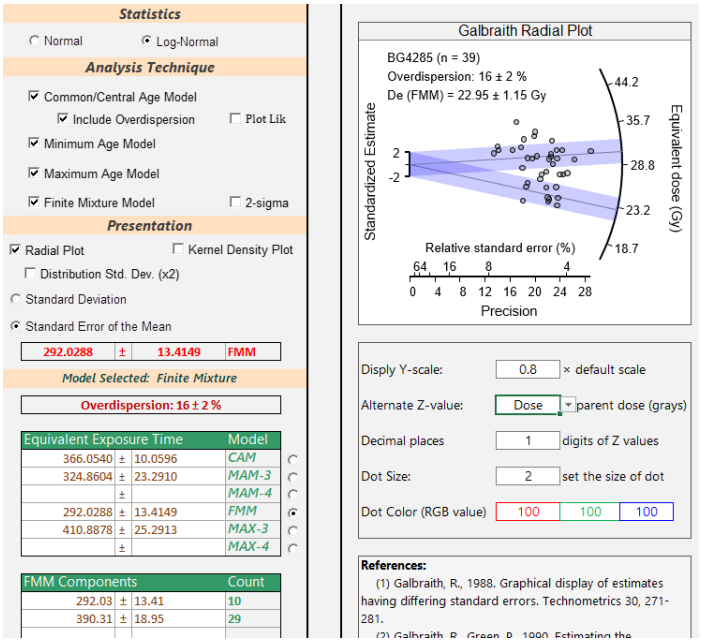


- If the value as the final De has been chosen via the corresponding option button, this value will also be as a reference value in the plot. The final De in grays and the age model used (e.g., CAM) will be marked on the plot as well.

- The appearance of the plot can be adjusted via changing the values, such as Y-scale, Z unit, decimal places, dot size, dot color, below the plot.
- The conversion of the dose unit for z-axis is based on the source dose rate (see section 1.2.2).
- The unit of Z-axis between Time (seconds) and Dose (Grays) can easily be switched.

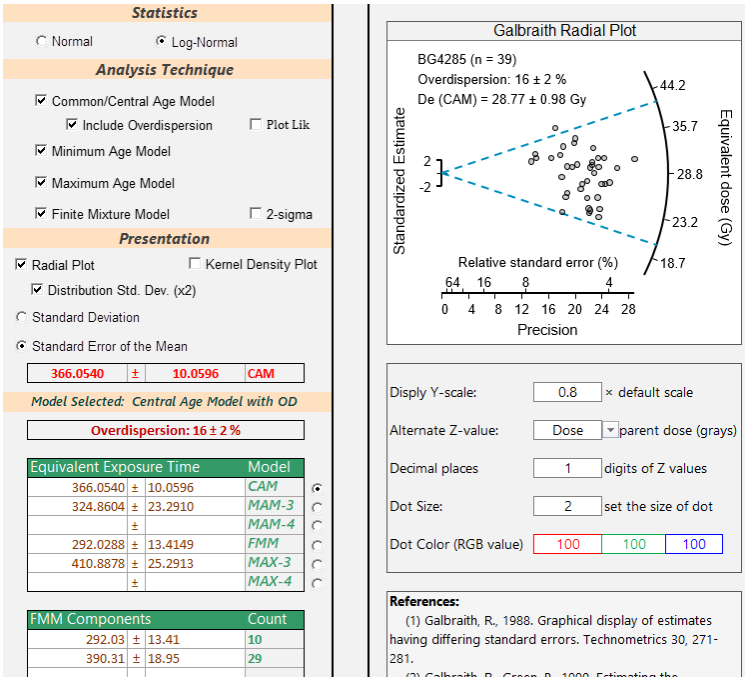


- If the results from the Finite Mixture Model (FMM) are chosen, all components will be plotted on the figure.



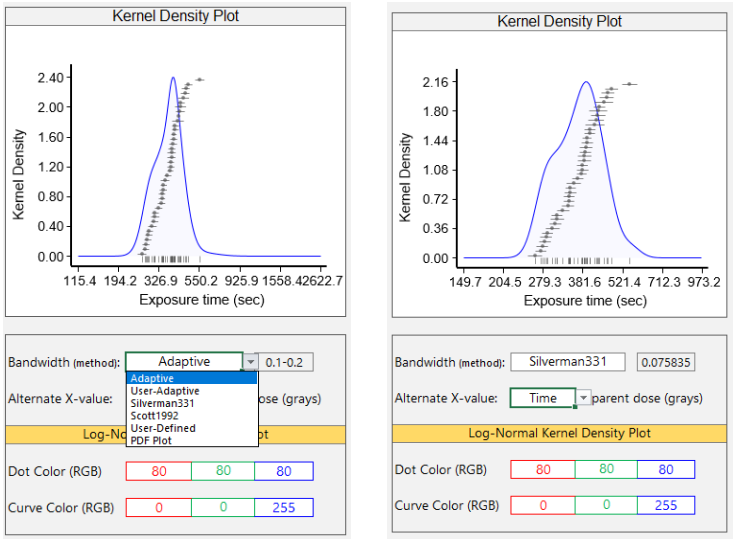
- When the "Radial Plot" checkbox is ticked, the "Distribution Std. Dev. (X2)" checkbox will be enabled. It can be used to identify the outliers. If the "Radial Plot" is unchecked, the Distribution Std. Dev. (X2) will be disabled, and the radial plot will be deleted.

- Both original and log-transformed data can be registered in a radial plot. Just choose via the statistics buttons at the top.

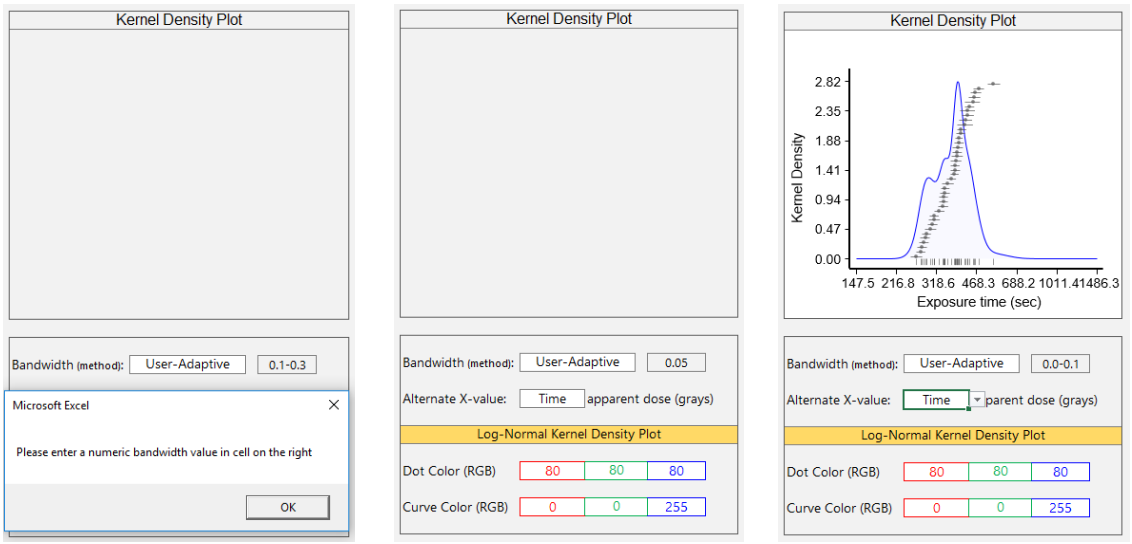


5.2.2 Kernel Density Plot

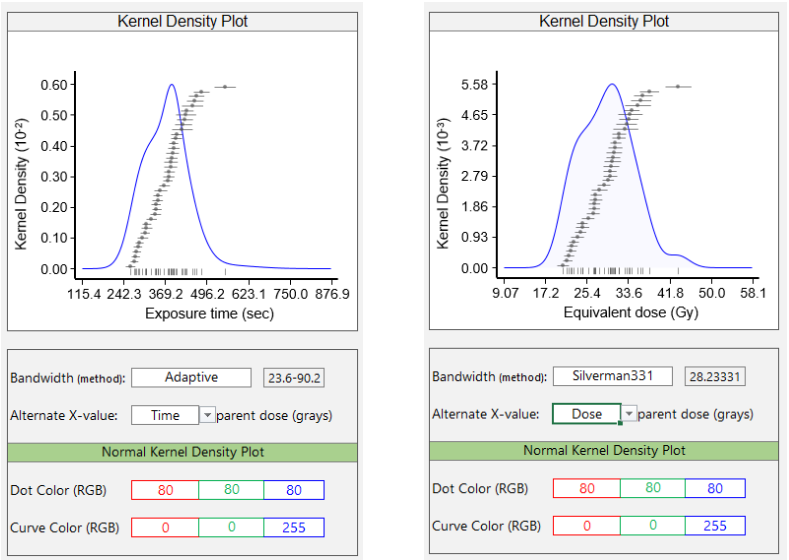
- The operation of kernel density estimates (KDE) plot is the same as the radial plot. Tick the checkbox "Kernel Density Plot" to create a KDE graph.
- The shape of the KDE plot depends on the bandwidth which is based on the "bandwidth (method)" used below the "**Kernel Density Plot**" panel.
- The default bandwidth method is "Adaptive", which customize the kernel bandwidth locally to account for variations in the density of the data. Thus, the final bandwidths of the "Adaptive" method are not a constant value. The bandwidth will present after the method cell on the right. There are five bandwidth options in the list.



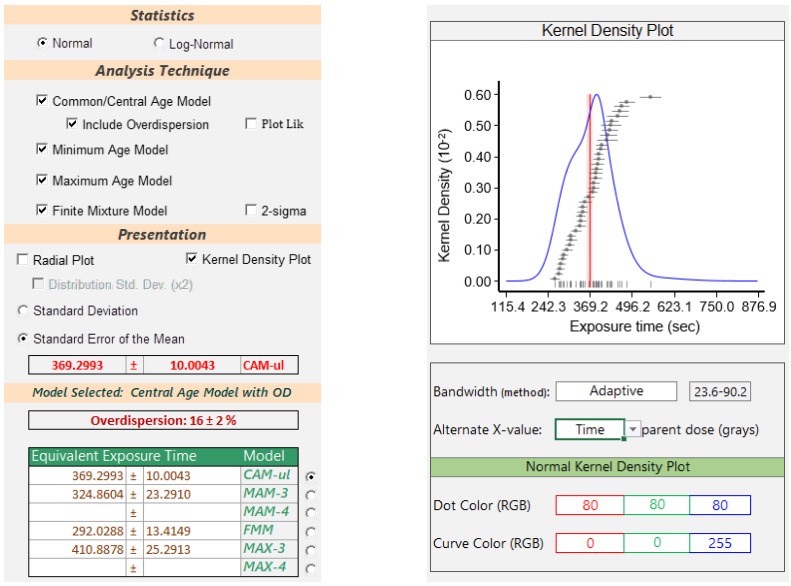
- If the "User-defined" or "User-adaptive" is chosen from the drop-down list for bandwidth method, the cell to the right of the bandwidth method must be a numeric value, otherwise, a warning message will pop up to show "*Please enter a numeric bandwidth value in a cell on the right*". In this case, users should input a numeric value as a global bandwidth, such as 0.05, and then plot again (see the figure below).



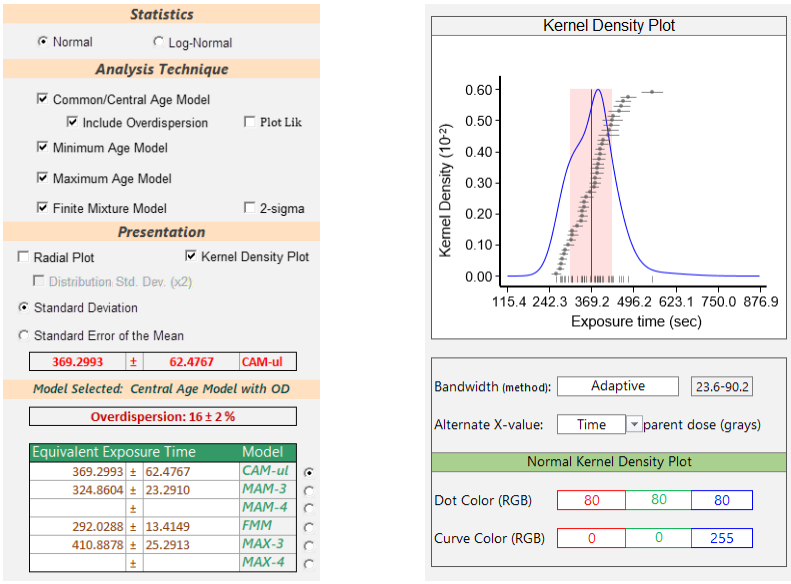
- After the KDE figure is created, the bandwidth will be automatically changed to a range (e.g., 0.0-0.1), because the adaptive bandwidth is used.
- The original data ("Normal" is ticked) can also be plotted as KDE figure, and the prompt message below the KDE plot will show "*Normal Kernel Density Plot*".
- As with the radial plot, the dose unit can also be switched between "sec" or "Gy".
- The following cases show that the adaptive bandwidth is a range between 23.6-90.2, while the bandwidth calculated by "Silverman331" is a constant value of 28.23.



- As with the radial plot, if the final De has been chosen, this value with its error will be plotted on the KDE graph.



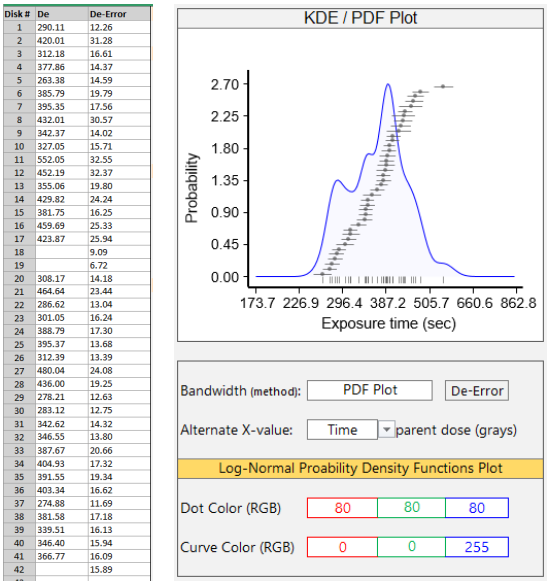
- The standard deviation also can be chosen to plot on the figure. The detail difference between standard error and standard deviation can be referred to Galbraith and Robert (2012).



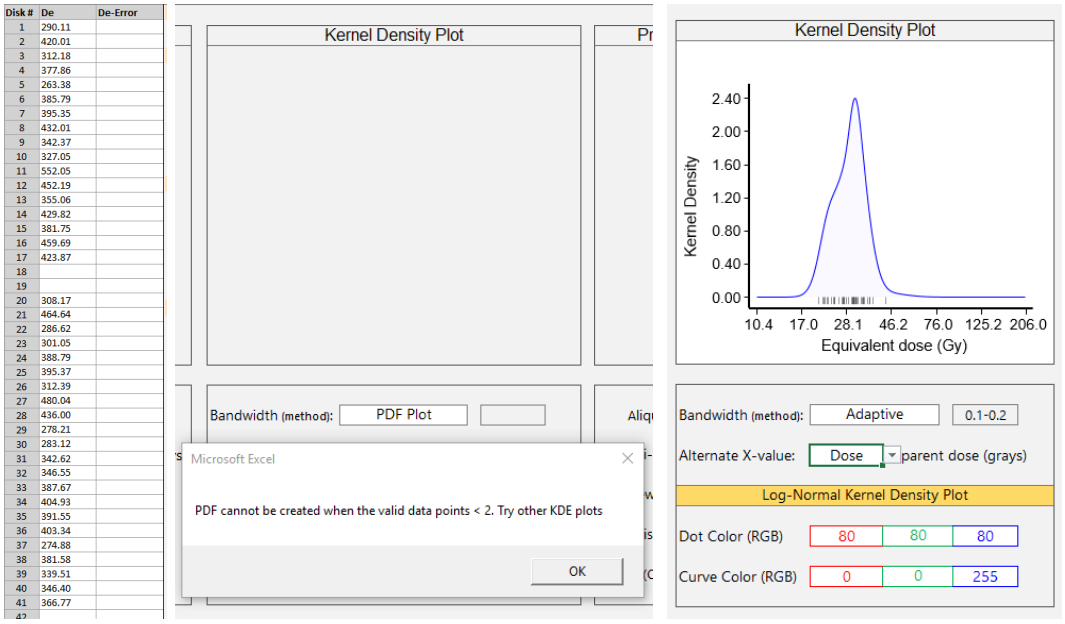
5.2.3 Probability Density Functions (PDF) Plot

- If the bandwidth “PDF Plot” is chosen, a probability density functions figure will be created, instead of KDE plot.
- The mathematical definition of a PDF plot closely resembles that of the KDE, the only difference being the substitution of the bandwidth “h” by the analytical uncertainty “De-error”. From each individual observed De value with its error a probability density function (PDF) was calculated based on the Gaussian distribution and summed as the PDF plot.

- The KDE plot only uses the De data, whereas the “PDF Plot” uses the De values and associated errors.
- When the “PDF Plot” in the drop-down list is chosen, the bandwidth cell shows “De-Error” instead of specific values. The y-axis name will be changed to “Probability” instead of “Kernel Density” as with the KDE plot.



- If there is a set of De values without associated errors, only a “KDE plot” can be generated but not a “PDF Plot”. The prerequisite for creating PDF plot in LDAC is that there are at least 2 data points which have values and errors.

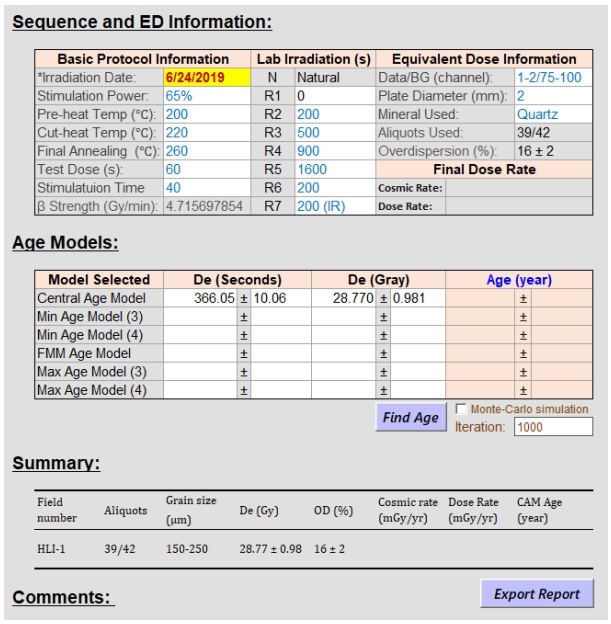


5.2.4 Clear contents

- The button “Clear Contents” is used to clear all inputs, outputs, figures, and settings on the “*De Calculation*” page if necessary.

6. Dose Rate and Final Age Calculation

- The dose rate and final age calculation are performed on the "*Summary*" page. After all analyses and visualizations have been finished on the "*De Calculation*" page, users can click the worksheet "*Summary*" on the bottom to go back to the "*Summary*" page.



Sequence and ED Information:

Basic Protocol Information		Lab Irradiation (s)		Equivalent Dose Information	
*Irradiation Date:	6/24/2019	N	Natural	Data/BG (channel):	1-2/75-100
Stimulation Power:	65%	R1	0	Plate Diameter (mm):	2
Pre-heat Temp (°C):	200	R2	200	Mineral Used:	Quartz
Cut-heat Temp (°C):	220	R3	500	Aliquots Used:	39/42
Final Annealing (°C):	260	R4	900	Overdispersion (%):	16 ± 2
Test Dose (s):	60	R5	1600	Final Dose Rate	
Stimulatuion Time	40	R6	200	Cosmic Rate:	
β Strength (Gy/min):	4.715697854	R7	200 (IR)	Dose Rate:	

Age Models:

Model Selected	De (Seconds)			De (Gray)			Age (year)		
Central Age Model	366.05	±	10.06	28.770	±	0.981		±	
Min Age Model (3)		±			±			±	
Min Age Model (4)		±			±			±	
FMM Age Model		±			±			±	
Max Age Model (3)		±			±			±	
Max Age Model (4)		±			±			±	

Find Age ☐ Monte-Carlo simulation Iteration: 1000

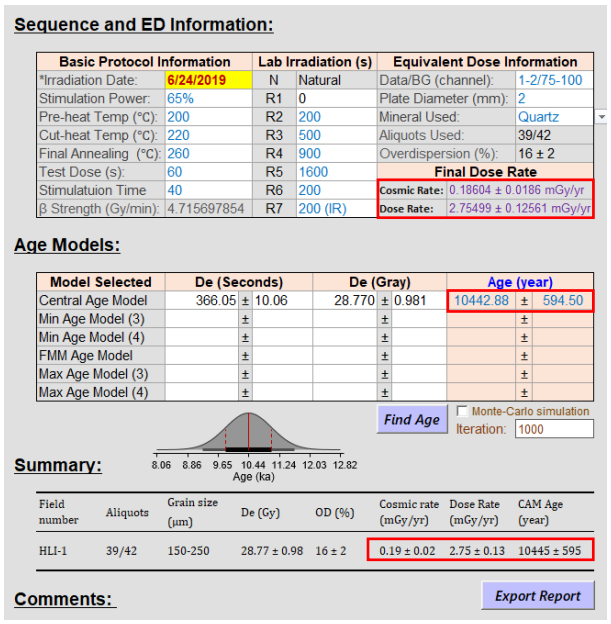
Summary:

Field number	Aliquots	Grain size (μm)	De (Gy)	OD (%)	Cosmic rate (mGy/yr)	Dose Rate (mGy/yr)	CAM Age (year)
HLI-1	39/42	150-250	28.77 ± 0.98	16 ± 2			

Comments: Export Report

6.1 Default Dose Rate Calculations

- The next step is to calculate the dose rate and the final age via pushing the "Find Age" button, under the "**Age Models**" panel.



Sequence and ED Information:

Basic Protocol Information		Lab Irradiation (s)		Equivalent Dose Information	
*Irradiation Date:	6/24/2019	N	Natural	Data/BG (channel):	1-2/75-100
Stimulation Power:	65%	R1	0	Plate Diameter (mm):	2
Pre-heat Temp (°C):	200	R2	200	Mineral Used:	Quartz
Cut-heat Temp (°C):	220	R3	500	Aliquots Used:	39/42
Final Annealing (°C):	260	R4	900	Overdispersion (%):	16 ± 2
Test Dose (s):	60	R5	1600	Final Dose Rate	
Stimulatuion Time	40	R6	200	Cosmic Rate:	0.18604 ± 0.0186 mGy/yr
β Strength (Gy/min):	4.715697854	R7	200 (IR)	Dose Rate:	2.75499 ± 0.12561 mGy/yr

Age Models:

Model Selected	De (Seconds)			De (Gray)			Age (year)		
Central Age Model	366.05	±	10.06	28.770	±	0.981	10442.88	±	594.50
Min Age Model (3)		±			±			±	
Min Age Model (4)		±			±			±	
FMM Age Model		±			±			±	
Max Age Model (3)		±			±			±	
Max Age Model (4)		±			±			±	

Find Age ☐ Monte-Carlo simulation Iteration: 1000

Summary: 8.06 8.86 9.65 10.44 11.24 12.03 12.82 Age (ka)

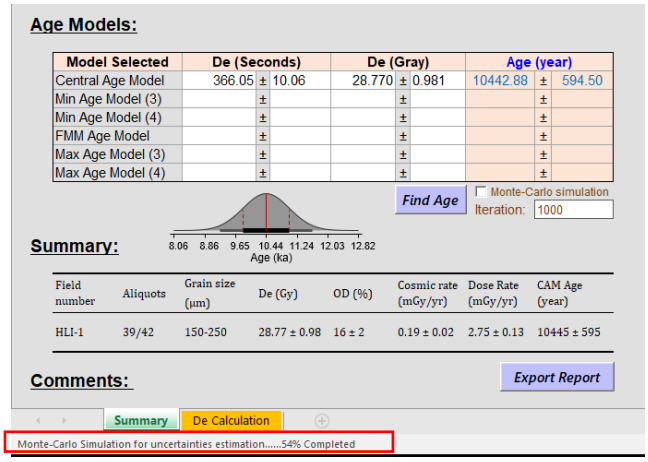
Field number	Aliquots	Grain size (μm)	De (Gy)	OD (%)	Cosmic rate (mGy/yr)	Dose Rate (mGy/yr)	CAM Age (year)
HLI-1	39/42	150-250	28.77 ± 0.98	16 ± 2	0.19 ± 0.02	2.75 ± 0.13	10445 ± 595

Comments: Export Report

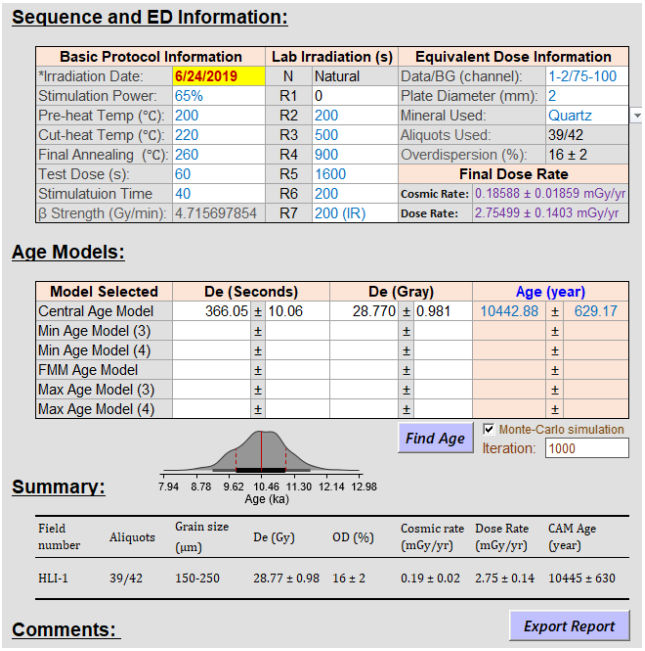
- The results will immediately appear on the "**Age Models**" table, associated with the corresponding age model chosen in the "*De Calculation*" page. The rounded values will be displayed in the summary table.

6.2 Monte-Carlo Dose Rate

- If the checkbox "Monte-Carlo simulation" is ticked before pushing the "Find Age" button, the uncertainties of dose rate and final age will be calculated by Monte Carlo simulation.
- By default, the Monte-Carlo simulation will repeat 2000 times. This value can be modified at will. The more iterations, the more time the program will take to generate the final result. When the Monte Carlo simulation is executed, the status bar at the bottom will show the progress.

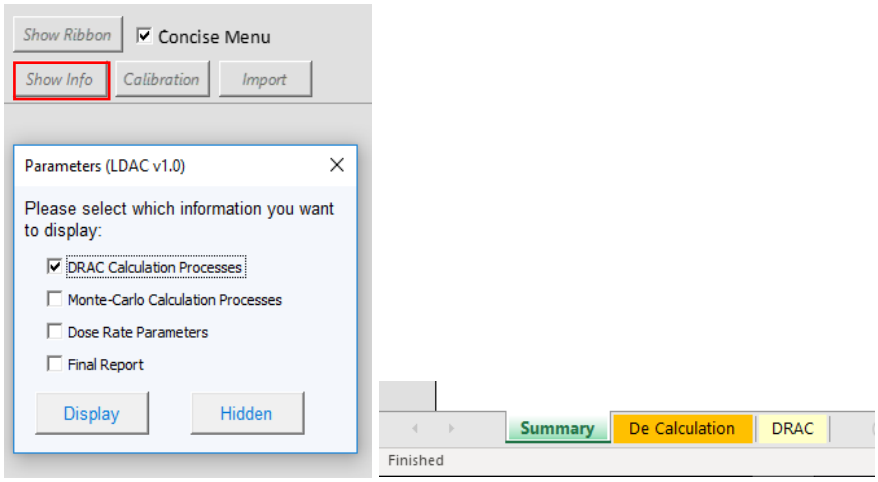


- Note that because the Monte Carlo approach is based on a stochastic sampling of all input values based on their mean and standard deviation, the final error will vary slightly each time the Monte Carlo routine is run. However, the central value (10442.88 yr in the example below) is based on the input values and is not derived from the Monte Carlo results. The marginal density of the Monte Carlo Results, 1σ and 2σ errors are presented above the summary table.

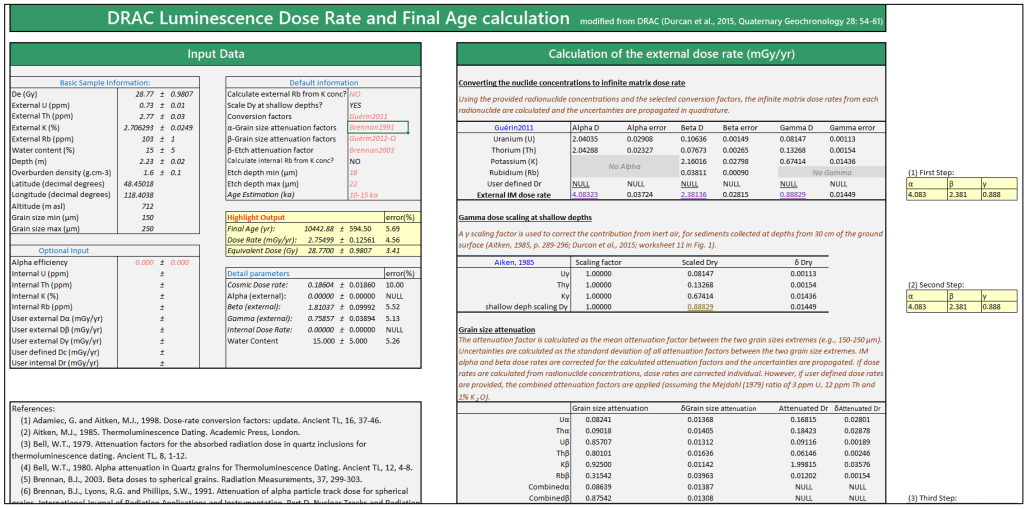


6.3 Show the calculation processes

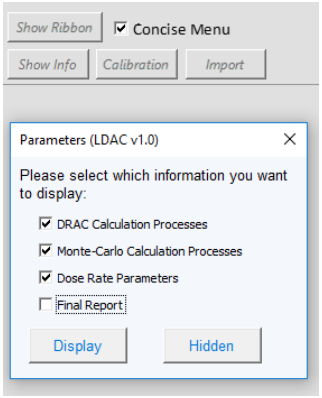
- Users can engage the "Show Info" button on the upper-right corner to display the backstage calculation processes.

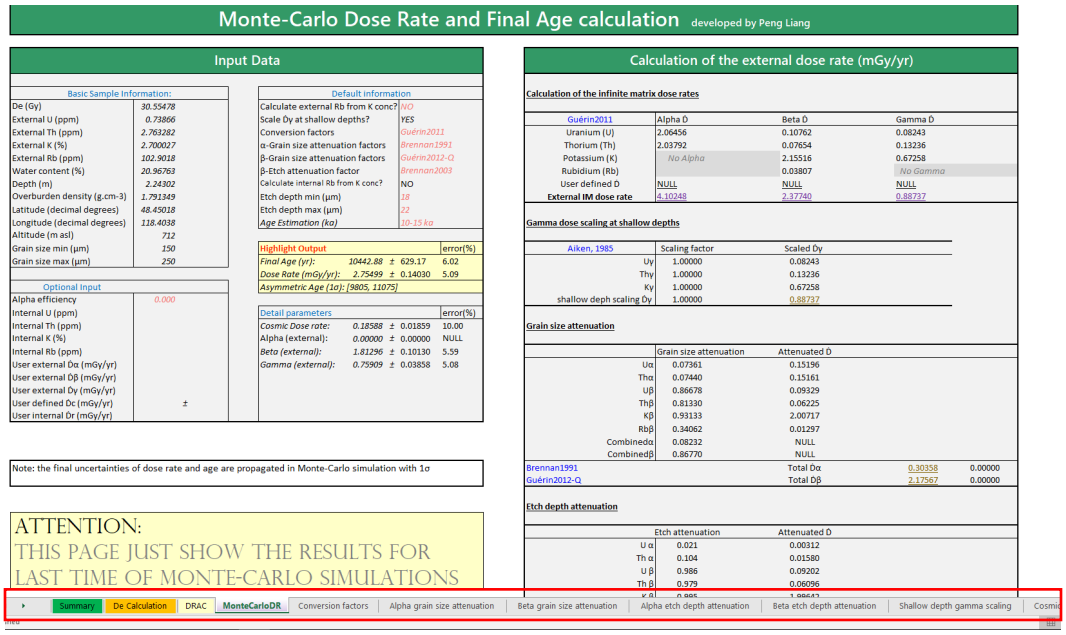


- Click the worksheet name "*DRAC*" to activate the "*DRAC*" page (default calculation method).

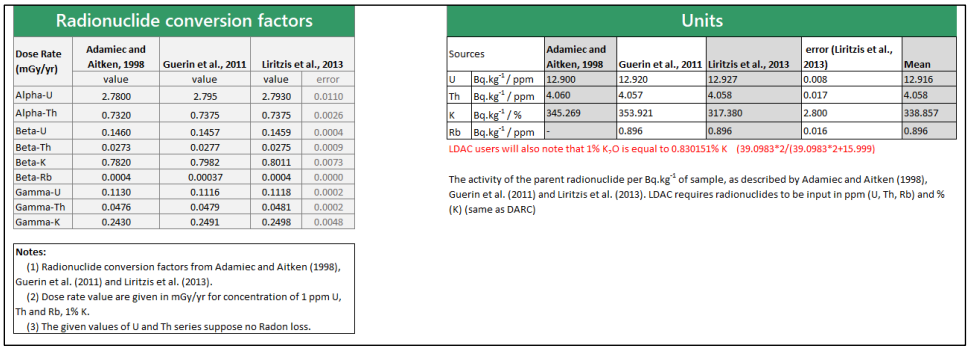


- If users want to display more information about the dose rate calculation and parameters, tick the associated checkbox on the "Show Info" dialog box.





- All parameters can be checked via clicking the corresponding name of the worksheet. For example, below shows the conversion factors.



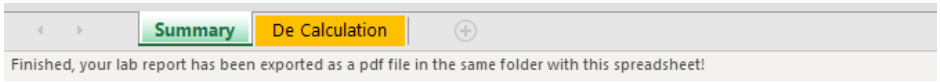
6.4 Hide the extra worksheet

- Users can push the "Hide" button on the "Show Info" dialog box to hide all extra worksheet (except the "*Summary*" and "*De Calculation*" page).

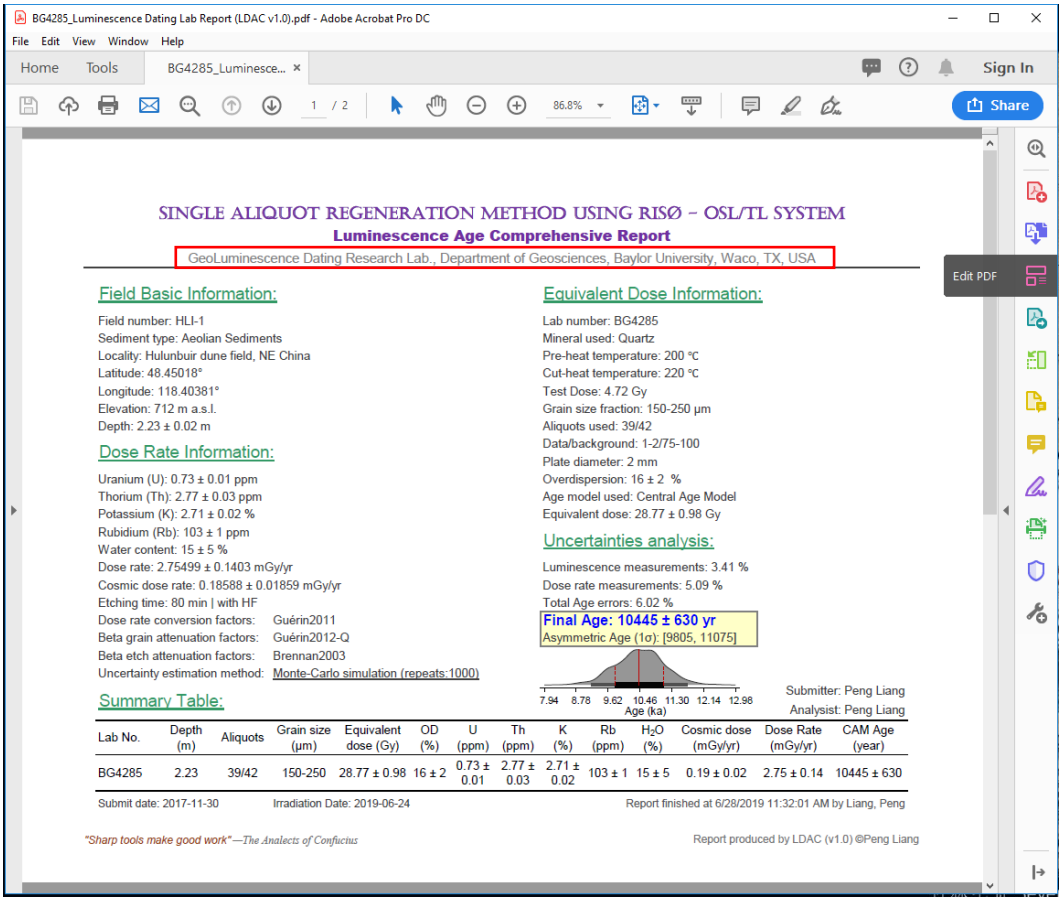
7. Export Report

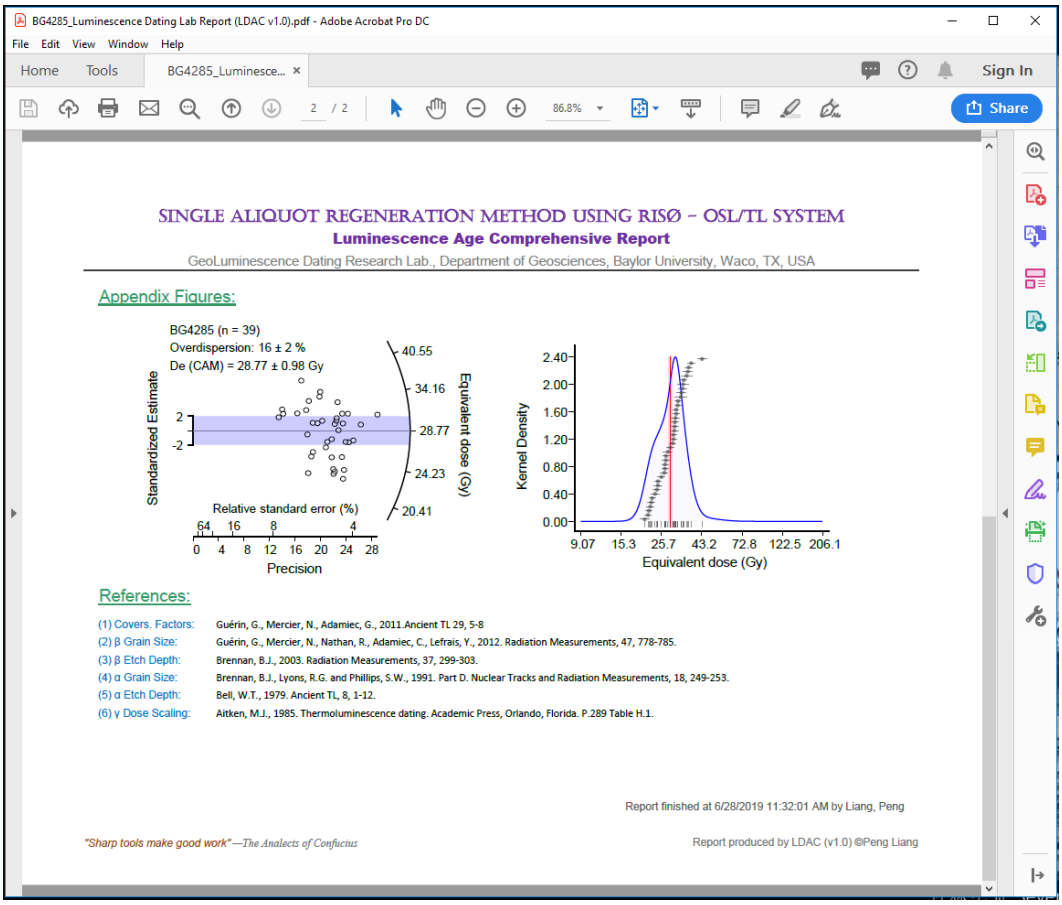
Note: Remember to click the "Save Results" button at any time.

- When all analyses and calculation have been finished, users can push the "Export Report" button to export the highlighted results as a "*.pdf" lab report.
- When this exporting process is finished, the status bar at the bottom will show a prompt message "*Finished, your lab report has been exported as a pdf file in the same folder with this spreadsheet*".

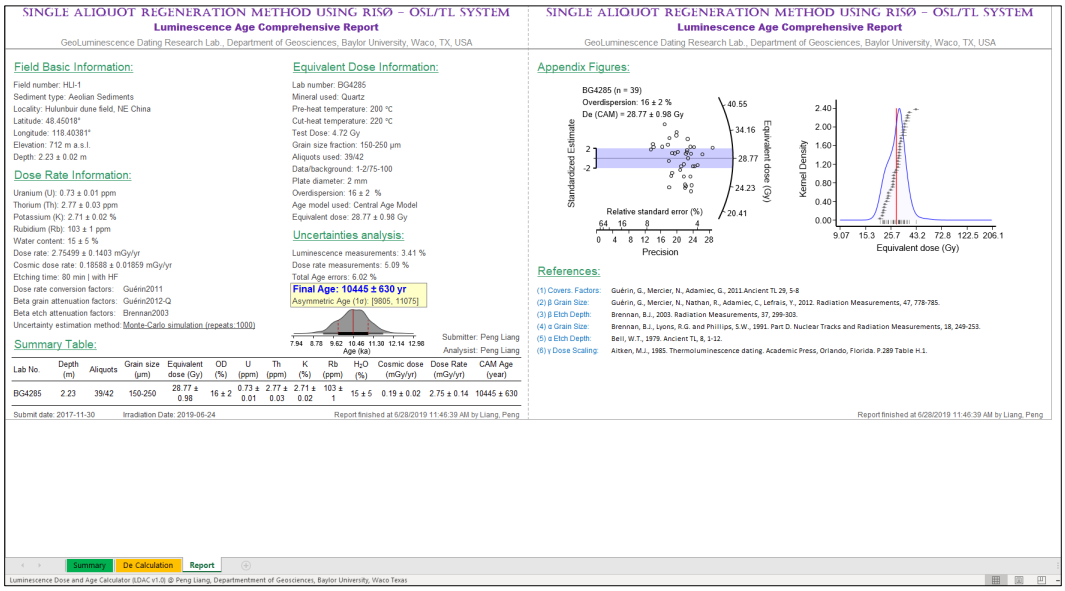


- This lab report will be named as "*BG4285_Luminescence Dating Lab Report (LDAC v1.0).pdf*" based on the "Lab number" input in the "**Sample Information**" panel, and it will be automatically saved in the same folder with this Excel file. The laboratory's name shown on this report is from the lab's name of the "Calibration" (see section 1.2.2). All information, graphs, and parameters used are explicit in this lab report.



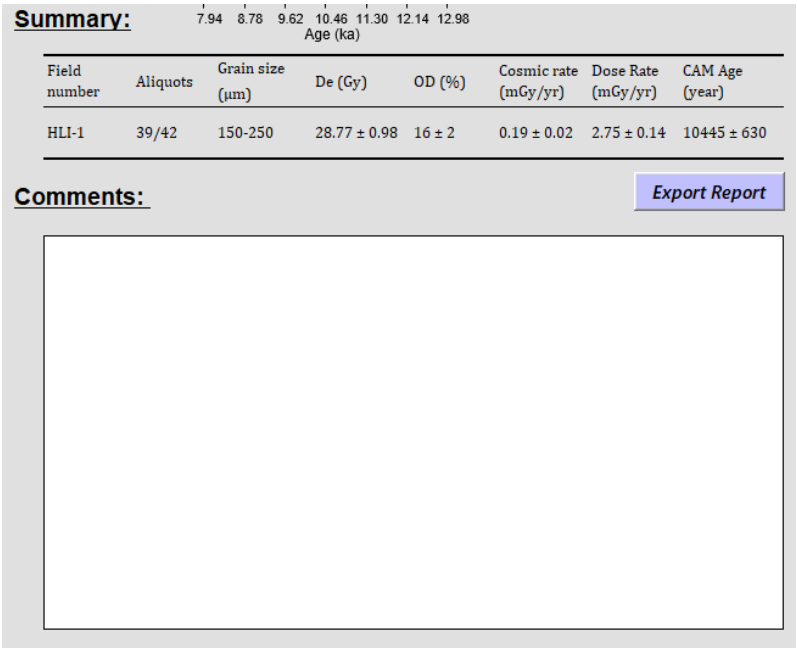


- If users want to copy the full version of the summary table for publishing, click the "Show Info" button and tick the "Final Report" checkbox and display it. The password here is ";".
- A "Report" worksheet will be activated. Users can copy the table or change the laboratory' name. Changing the lab's name via the "Calibration" is a better way (see section 1.2.2).

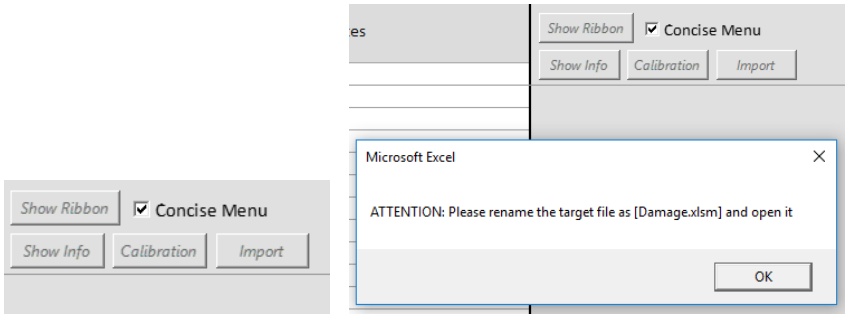


8. Additional information

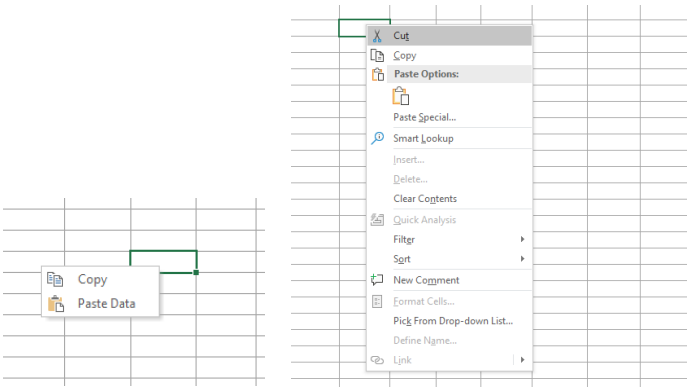
- If there is any supplementary information related to the analyzed sediments, a "**Comments**" space below the summary table can be used to input.



- Sometimes the stored file cannot be further operated, and it can just be previewed. In this case, users can modify the name of that file to "*Damage.xlsm*", and then open a new LDAC to import the data from the damaged file via the "Import" button on the right-top corner.
- Please keep the damaged file "Damage.xlsm" open when import the data, otherwise a prompt message will be popped up.

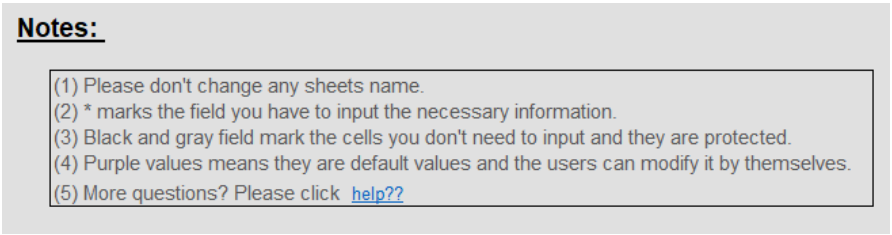


- The checkbox "Concise Menu" is used to change the Right-click menu.
- The original right-click menu of the Microsoft Excel is modified to a concise version in the "Summary" page of LDAC to ensure that the structure of the worksheet cannot be changed.
- This concise version of the Right-click menu ensures all paste operations in LDAC is plain text, but the original functions of right-clicking can also be used via unticking the checkbox "Concise Menu".
- This operation is **NOT** recommended due to it increases the risk to change the potential structure of LDAC and then affect the correctness.



9. Feedback

- Although we have tried this program in lots of computers with different language version of Windows and Microsoft Excels, we believe that users may still encounter some unknown errors and bugs.
- Users can click help?? on the "**Notes**" panel of the "*Summary*" page to send a feedback email or can directly email to Peng Liang (Peng_Liang1@baylor.edu; LiangPeng2012@live.cn; LiangPeng@mail.iggcas.ac.cn). We will get back to you as soon as possible.



- Any bug-reports, suggestions, and even requirements for further developing the LDAC are warmly welcome.