User's Manual of "*TAgen_pred.py*"

Version 1.1

(27 Aug, 2025)

Table of contents

1. Overview

■ Outline:

- The "***TAgen_pred.py***" is a simulation tool for generating a "***TA***" *(*averaged atomic time scale) with daily prediction and fixed clock weights of atomic clocks.
- This "***TA* with prediction**" is explained as "***TAp***" in the relevant tutorial lecture *[Ref. 1]*.

■ Aim:

- To learn step by step the process of making "***TA* with prediction**", this program adopts fixed weighting. This means that the weights keep the initial value throughout the entire calculation period.
- You can investigate how the ***TA*** changes when you change the combination of clocks, parameter for the prediction, and initial weight of each clock.

※ To learn the principle of ***TA*** at first, another simpler algorithm is desirable. Please refer to the tutorial lecture of "***TA* by basic averaging**" (*"**TAb**" [Ref. 1])* and the program manual of "***TAgen_basic.py***".

※ For more optimal and practical ***TA***, the advanced algorithm is desirable. Please refer to the manual of "***TAgen_auto.py***".

■ Technical comments:

- The program requires the measurement "***UTC(k)-clock$_i$***" data files, parameter tables "***clock_file_list.txt***" and "***param_list.txt***" located under the designated directory and folders.
- The frequency stabilities of the clock data and the calculated ***TA*** are evaluated using Allan Deviation (*ADEV*), which is calculated using the free Python library "***AllanTools***" *[Ref. 2]*.

■ Reference:

[1] Y. Hanado, "*Time scale algorithms ~basics to applications~ Lecture*", BIPM Summer School, September 11, 2025

[2] Web site of *"AllanTools" (https://allantools.readthedocs.io/en/latest/)*

2. Setting of environment

[1] Install *Python in your computer*

- Set the path to the working directory.
- The following Python modules should be installed in advance;

  - *numpy*
  - *matplotlib*
  - *allantools*

For example, from the command prompt;

```
C:\Mywork>python -m pip install numpy
```

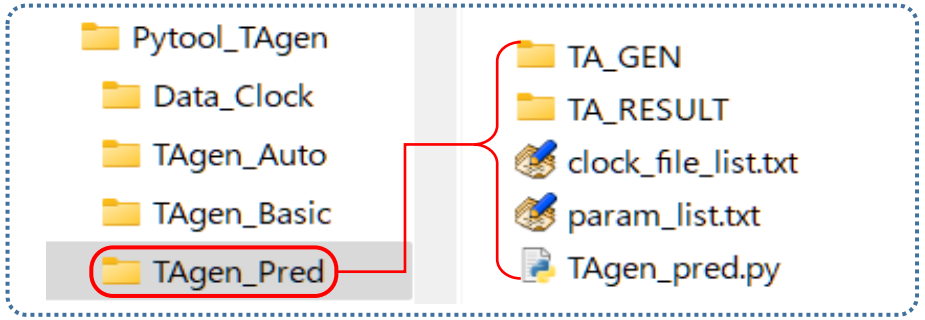
※ Although *"Spyder"* is not necessary for running the tools, it is useful for debugging and modifying them.

https://www.spyder-ide.org/

[2] Construct directories :

Make ***"/Pytool_TAgen"***,
"/Pytool_TAgen/TAgen_Pred",
"/Pytool_TAgen/TAgen_Pred/TA_GEN/", ***and***
"/Pytool_TAgen/TAgen_Pred/ TA_RESULT/".

- The directory name "***Pytool_TAgen***" can be changed as you like, but **don't change the names of the directories under *"/Pytool_TAgen/"*.**



3. Preparation for starting the program

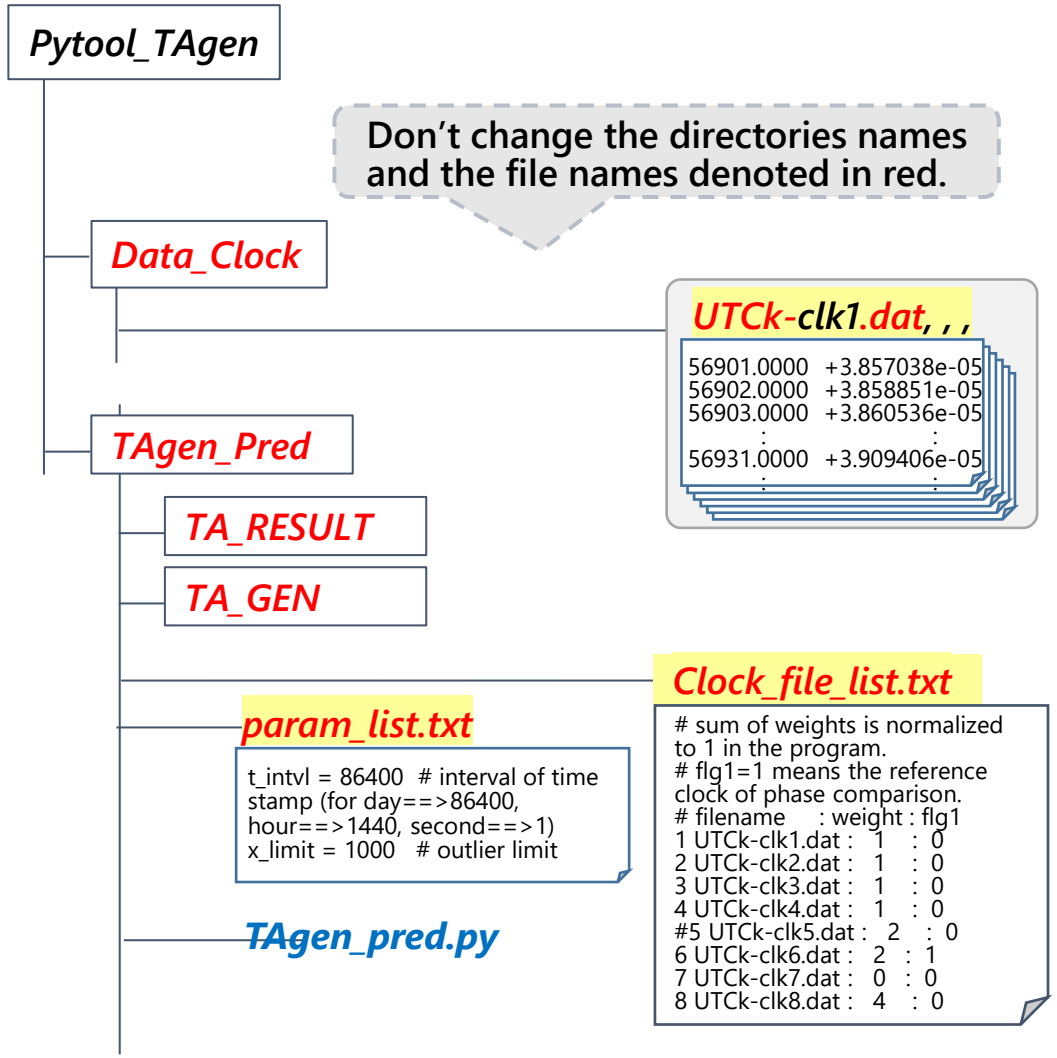
TAgen_pred.py

[1] Copy the Python program : "*TAgen_pred.py*"

[2] Copy or make the necessary files :

- Clock measurement data :
  "*/Pytool_TAgen/Data_Clock/UTCk-(clock$_i$).dat*" *(p.27)*
  - The "***UTCk-(clock$_i$).dat***" are measurement clock data used for the TAp calculation.
- Clock-data name list file :
  "/Pytool_TAgen/TAgen_Pred/clock_file_list.txt" (p.25)
  - *"**clock_file_list.txt**"* provides the conditions of each clock in the averaging process.
- Parameter list file :
  "/Pytool_TAgen/TAgen_Pred/param_list.txt"(p.26)
  - Parameters that are fixed within the program but can be changed on demand are provided in "***param_list.txt***".

※ Details of each file are provided in *Appendix A-1.2.*



4. Operation of each function

4.1. Run "*/TAgen_Pred/TAgen_pred.py*"

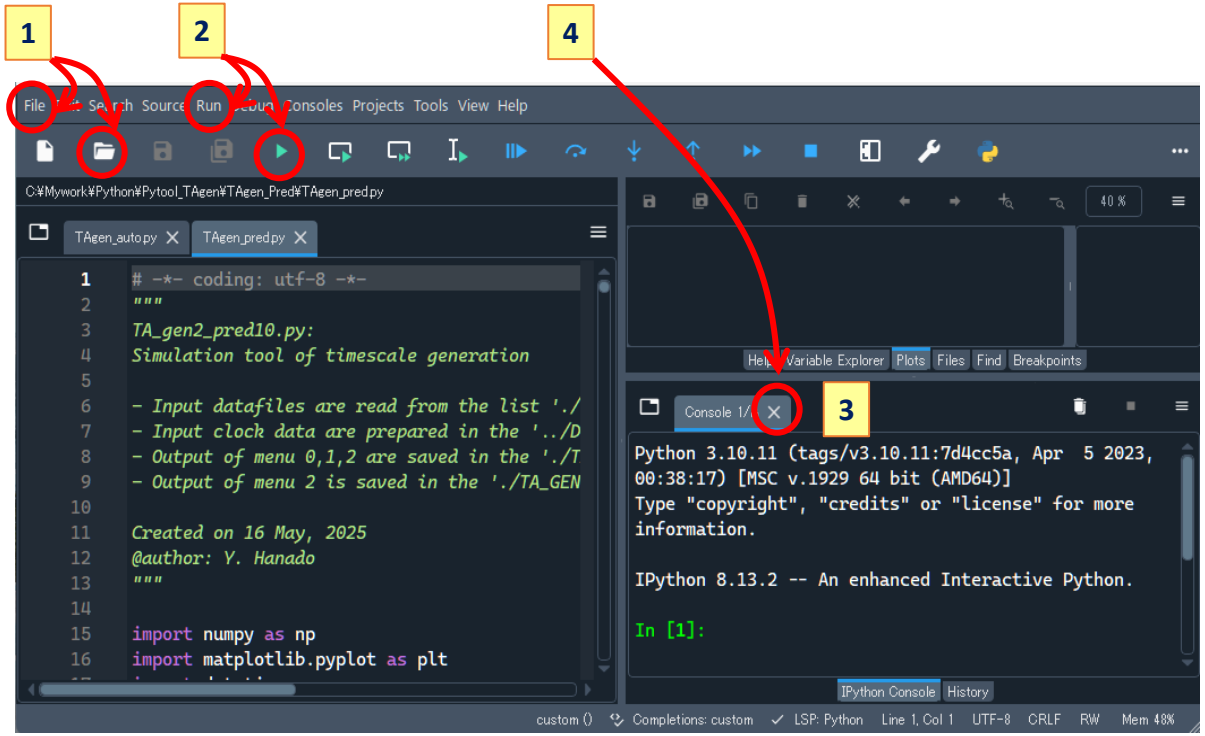
■ Case-1 : via "*Spyder*"

[1] Select the following Python program from the menu of "***File --> open ->*** ***/Pytool_TAgen/TAgen_Pred/TAgen_pred.py***". 1

[2] Click " ▶ " or "***Run***". 2

※ The result is shown in the "***Console***" window. 3

※ You can exit the program by clicking "***X***" on the Console window. 4



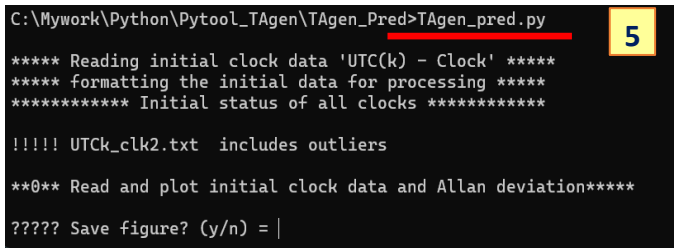
■ Case-2 : via "Command Prompt"

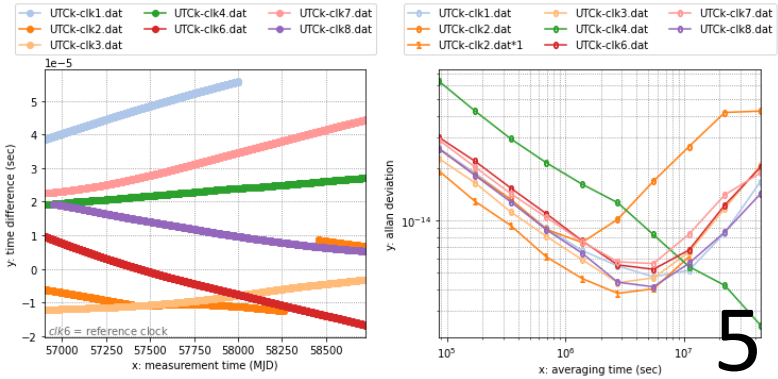
[1] Go to the directory including "***TAgen_pred.py***" in advance.

[2] Run "***TAgen_pred.py***" --> You can proceed with the program in the command prompt console. 5

※ The graph is shown in another window. 6

※ You can exit the program by "***Ctrl+Z***".





4. Operation of each function

TAgen_pred.py

4.1. Run "*/TAgen_Pred/TAgen_pred.py*"

■ Initial processing

[1] Read the parameters from "*param_list.txt*" *(p. 26)*

- Parameters that are fixed within the program but can be changed on demand are provided from this parameter list.

[2] Read the parameter from "*clock_file_list.txt*" *(p. 25)*

- This parameter list provides the conditions of each clock in the averaging process.
- The clocks expected to be used in the ***TAp*** calculation are assigned here with some weights.

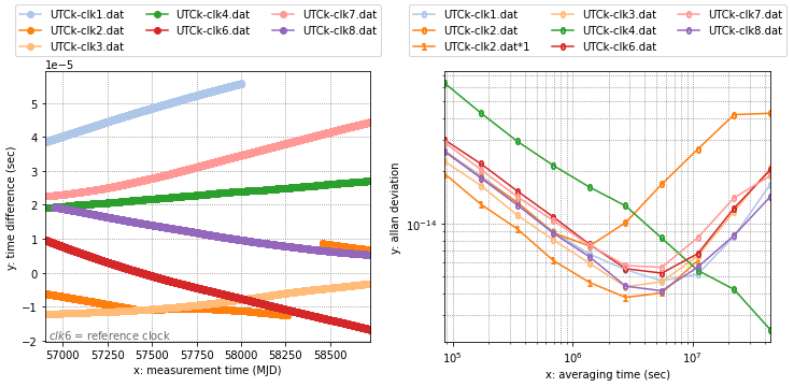
[3] Read the assigned clock data "*UTCk-(clock$_i$).dat*" *(p. 27)*

- Clocks with "***weight=0***" are not ignored in this initial process but excluded in the averaging process of "*menu-2*". 1
- Alert of outlier : outlier limit is set in "***param_list.txt***".

[4] Fix the available MJD range

- The available data range ***[MJD1, MJD2]*** is set as wide as possible.
- The MJD with enough number of clocks can be available.
- In all assigned clock data files, the available oldest date is set to be ***MJD1*** and the latest date is set to be ***MJD2***.

```
Python 3.10.11 (tags/v3.10.11:7d4cc5a, Apr  5 2023, 00:38:17)
[MSC v.1929 64 bit (AMD64)]
Type "copyright", "credits" or "license" for more information.

IPython 8.13.2 -- An enhanced Interactive Python.

runfile('C:/Mywork/Python/Pytool_TAgen/TAgen_Pred/TAgen_pred.
py', wdir='C:/Mywork/Python/Pytool_TAgen/TAgen_Pred')

..... Reading initial data of 'UTC(k) - Clock'
..... formatting the initial data for processing

************ Initial status of all clocks ************

!!!!! UTCk-clk2.dat  includes outliers  1
```




```
**0** Read and plot initial clock data and Allan deviation*****

????? Save figure? (y/n) =
```

4. Operation of each function

4.1. Run "*/TAgen_Pred/TAgen_pred.py*"

■ Initial processing (Cont.)

[5] Combine the clock data within the assigned range

- The combined data file is "***all_raw_clk.dat***". *(p.32)*
- If data is missing, "***nan***" is recorded.

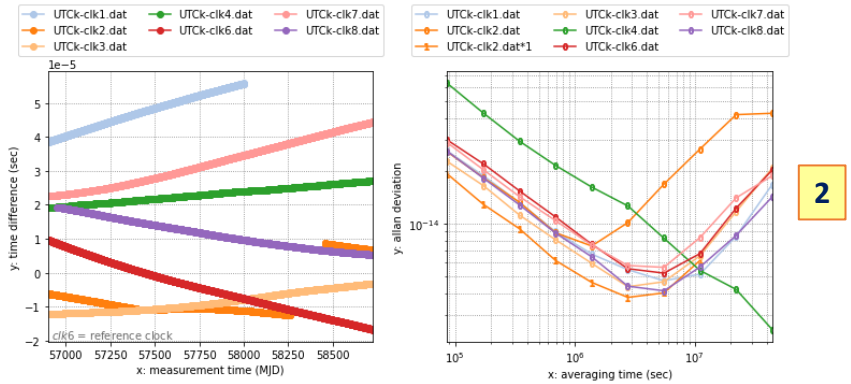
[6] Plot all the clock data of "***UTC(k) – clock$_i$***" *(p.37)* 2

- From the plots, clock conditions can be confirmed.
  - Left fig. : time difference of "***UTC(k) – clock$_i$***".
  - Right fig. : *ADEV* of "***UTC(k) – clock$_i$***".

※ *ADEV* is calculated by "***AllanTools***" *[Ref. 2]*, and saved in "***all_adev.dat***". *(p.34)*

[7] Save the results, if required

- If input "***y***" for "*Save figure (y/n) = "* , 3
  four results are saved under the following directory:
  "***./TA_RESULT/(time)/***" with a time stamp of data saving.
  - ***log_(time).txt*** : history of the process *(p.36)*
  - ***fig _(time).pdf*** : all figures *(p.37)*
  - ***all_raw_clk_(time).dat*** : "***UTC(k) – clock$_i$***" *(p.33)*
  - ***all_adev_(time).dat*** : *ADEV* of "***UTC(k) – clock$_i$***" *(p.34)*



2

0 Read and plot initial clock data and Allan deviation*****

????? Save figure? (y/n) = y 3

::::: save logfile = ./TA_RESULT/0717_093343/log_0717_093343.txt
::::: save figfile = ./TA_RESULT/0717_093343 /fig_0717_093343.pdf
::::: save alldata = ./TA_RESULT/0717_093343/all_raw_clk_0717_093343.dat
::::: save ADEVdat = ./TA_RESULT/0717_093343 /all_adev_0717_093343.dat

==========
Menu of the data processing
---
0. Plot the "UTC(k)-Clock" data
1. Assign the MJD range
2. Make TA with daily prediction
and fixed clock weights
10. Exit
==========
????? Input menu number ? >>

4. Operation of each function

TAgen_pred.py

4.1. Run "*/TAgen_Pred/TAgen_pred.py*"

Clock_file_list.txt

```
# sum of weights is normalized
to 1 in the program.
# flg1=1 means the reference
clock of phase comparison.
# filename    : weight : flg1
1 UTCk-clk1.dat :  1   : 0
2 UTCk-clk2.dat :  1   : 0
3 UTCk-clk3.dat :  1   : 0
4 UTCk-clk4.dat :  1   : 0
#5 UTCk-clk5.dat :  2   : 0
6 UTCk-clk6.dat :  2   : 1
7 UTCk-clk7.dat :  0   : 0
8 UTCk-clk8.dat :  4   : 0
```

UTCk-clk1.dat

56901.0000	+3.857038e-05
56902.0000	+3.858851e-05
:	:
57999.0000	+5.576701e-05
58000.0000	+5.578885e-05

- The combined data of all "***UTC(k)-clock$_i$***" except *clk5*.
- The ***weight***, ***flag*** and ***cid*** are the copies from "***Clock_flie_list.txt***".
- *ADEV*s are calculated from this data.

all_raw_clk_0717_093343.dat

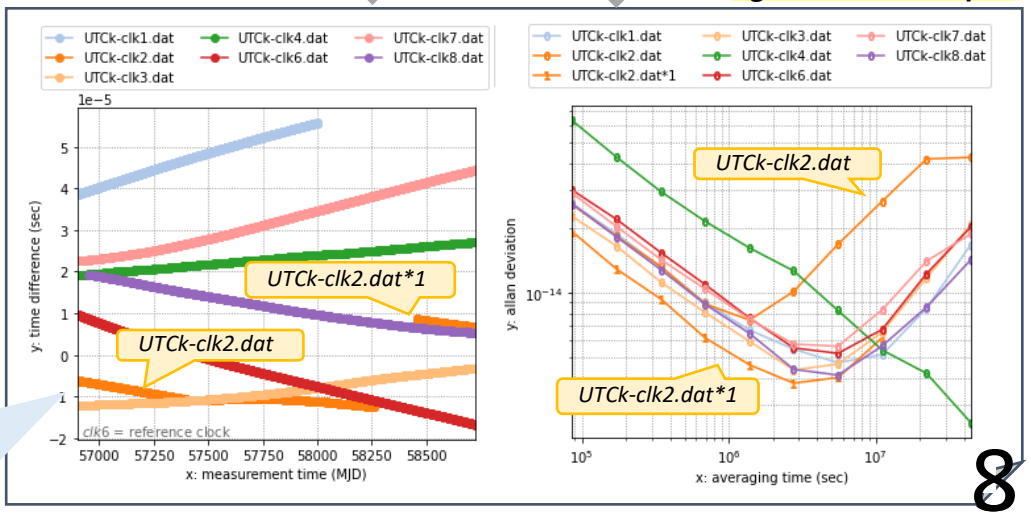
fname	UTCk-clk1.dat	UTCk-clk2.dat	UTCk-clk3.dat	UTCk-clk4.dat	UTCk-clk6.dat	UTCk-clk7.dat	UTCk-clk8.dat
Weight	1.0	1.0	1.0	1.0	2.0	0.0	4.0
flag	0	0	0	0	1	0	0
cid	1	2	3	4	6	7	8
56901	+3.857038e-05	-6.184638e-06	-1.215249e-05	+1.918367e-05	+9.635976e-06	+2.258480e-05	+nan
56902	+3.858851e-05	-6.197517e-06	-1.215115e-05	+1.919092e-05	+9.617261e-06	+2.258759e-05	+nan
:	:	:	:	:	:	:	:
58725	+nan	+6.693075e-06	-3.187783e-06	+2.707895e-05	-1.676407e-05	+4.440954e-05	+5.273111e-06
58726	+nan	+6.687379e-06	-3.180825e-06	+2.708426e-05	-1.677650e-05	+4.442301e-05	+5.270004e-06

all_adev_0717_093343.dat

Tau(s)	UTCk-clk1.dat	UTCk-clk2.dat	UTCk-clk2.dat*1	UTCk-clk3.dat	UTCk-clk4.dat	UTCk-clk6.dat	UTCk-clk7.dat	UTCk-clk8.dat
MJDspan	**56901-58000**	**56901-58260**	**58457-58726**	**56901-58726**	**56901-58726**	**56901-58726**	**56901-58726**	**56952-58726**
86400	+2.585226e-14	+2.559433e-14	+1.914455e-14	+2.255109e-14	+6.289309e-14	+2.989441e-14	+2.887262e-14	+2.576366e-14
172800	+1.871863e-14	+1.824332e-14	+1.284166e-14	+1.643061e-14	+4.258263e-14	+2.186610e-14	+2.024180e-14	+1.811728e-14
345600	+1.314144e-14	+1.320590e-14	+9.326690e-15	+1.116636e-14	+2.944345e-14	+1.532961e-14	+1.422621e-14	+1.275807e-14
:	:	:	:	:	:	:	:	:
22118400	+8.453397e-15	+4.172218e-14	+nan	+1.168016e-14	+4.207961e-15	+1.222042e-14	+1.399682e-14	+8.546454e-15
44236800	+1.668442e-14	+4.249225e-14	+nan	+2.068302e-14	+2.484683e-15	+2.016610e-14	+1.872125e-14	+1.418509e-14

- ***MJDspan*** is the period used in the *ADEV* calculation.
- If there are not sufficient samples, *ADEV* cannot be calculated and is expressed as "***nan***".

fig_0717_093343.pdf



log_0717_093343.txt

```
# Data log at 2025.07.17_09h33m_43s
#
**0** Read and plot initial clock data and Allan deviation*****
::::: Input clocklist  : clock_file_list.txt
::::: Input clock file : ['UTCk-clk1.dat', 'UTCk-clk2.dat', 'UTCk-clk3.dat',
'UTCk-clk4.dat', 'UTCk-clk6.dat', 'UTCk-clk7.dat', 'UTCk-clk8.dat']
::::: data time interval (t_intval): 86400(sec)
::::: Outlier limit (x_limit))    : 1000.0
```

- Operated menu processes are serially added to the log file.

- "***UTCk-clk2.dat***" includes anomalies on *MJD 58261 ~58456*, and they are treated as missing data.
- The data are divided into two blocks before/after the anomalies.
- *ADEV*s are calculated for each block.

4. Operation of each function

TAgen_pred.py

4.2. Select the menu of data processing

■ **Input the menu number** 1

0. Plot the "*UTC(k)* – *Clock$_i$*" data

- Read all the data assigned in "***clock_file_list.txt***" *(p. 25)*, and plot the time differences vs ***UTC(k)*** and their *ADEV*s.
- **This operation initializes all the processing to date.**

1. Assign the MJD range

- The specified range in this menu will be used for all subsequent processing unless "*menu-0*" is selected.

2. Make *TA* with daily prediction and fixed clock weights *1

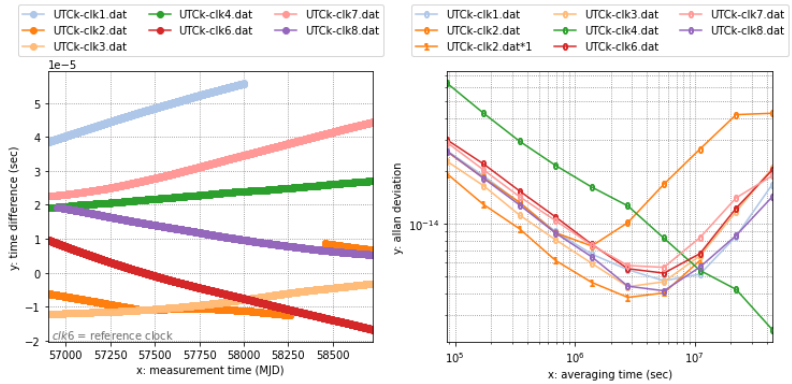
- Calculate the ***TAp*** using daily prediction.
- The clock weights are fixed depending on the values*2 given in "***clock_file_list.txt***".

10. Exit

- Exit the program.

1 : See **TAp in [Ref. 1].*

**2 : Normalized in the program.*



0 Read and plot initial clock data and Allan deviation*****

????? Save figure? (y/n) = y

::::: save logfile = ./TA_RESULT/0717_093343/log_0717_093343.txt
::::: save figfile = ./TA_RESULT/0717_093343 /fig_0717_093343.pdf
::::: save alldata = ./TA_RESULT/0717_093343/all_raw_clk_0717_093343.dat
::::: save ADEVdat = ./TA_RESULT/0717_093343 /all_adev_0717_093343.dat

==========
Menu of the data processing
---
0. Plot the "UTC(k)-Clock" data
1. Assign the MJD range
2. Make TA with daily prediction
and fixed clock weights
10. Exit
==========
????? Input menu number ? >> 1

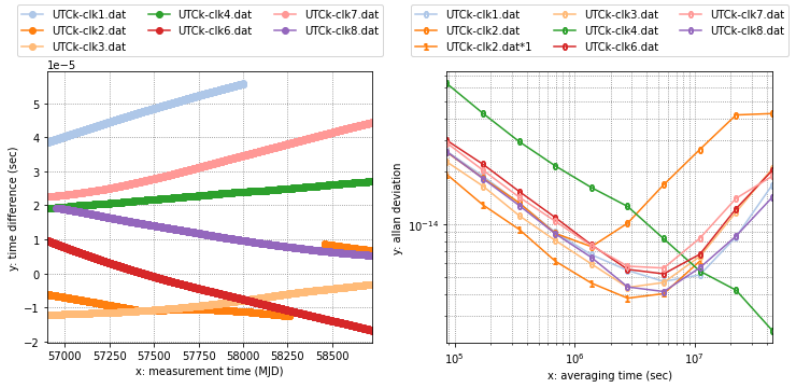
4. Operation of each function

TAgen_pred.py

4.2.1. If "*menu-0*" is selected: 1

- **Plot the "*UTC(k) – Clock$_i$*" data**
  - Function is the same as for the "*Initial processing [1]-[7]*". (*pp. 6-7*)
  - **Selecting this menu during operation will reset the results of the previous operation.**

```
=======================================
    Menu of the data processing
---------------------------------------
 0.  Plot the "UTC(k)-Clock" data
 1.  Assign the MJD range
 2.  Make TA with daily prediction
        and fixed clock weights
10.  Exit
=======================================
????? Input menu number ? >> 0   1

!!!!! UTCk-clk2.dat  includes outliers
```




```
**0** Read and plot initial clock data and Allan deviation*****

????? Save figure? (y/n) =
```

4. Operation of each function

TAgen_pred.py

4.2.2. If "*menu-1*" is selected: 1

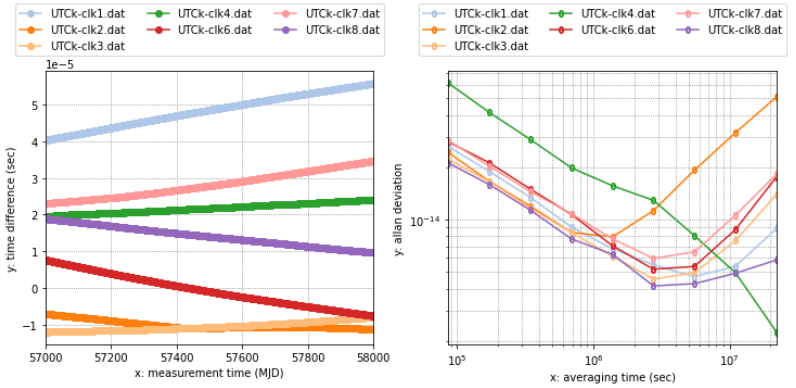
■ Assign the MJD range

- The targeted data range can be defined as [***MJD1, MJD2***].
- Enter ***MJD1*** and ***MJD2*** separated by a space. 2
- If the input values are outside the available range, re-entering is requested with an error message. 3
- If the input values are within the available range, the data processing range is updated. 4

  ※ **This new data range is adopted in any subsequent processes unless initialization is done using "*menu-0*".**

- Save the results, if required. 5

```
=======================================
    Menu of the data processing
---------------------------------------
 0.  Plot the "UTC(k)-Clock" data
 1.  Assign the MJD range
 2.  Make TA with daily prediction
        and fixed clock weights
10.  Exit
=======================================
????? Input menu number ? >> 1                    1
**1** Assign the MJD range for calculation in [56901,58726].
??1?? Input MJD1 and MJD2 with spacing = 56910 58800   2
**1** Selected range is : [ 56910  -  58800 ]
!!!!! MJD2 should be equal or smaller than  58726 . !!!!!   3
**1** Assign the MJD range for calculation in [56901,58726].
??1?? Input MJD1 and MJD2 with spacing = 57000 58000   4
 **1** Selected range is : [ 57000  -  58000 ]
```




```
**0** Read and plot initial clock data and Allan deviation*****
????? Save figure? (y/n) =                        5
```

4. Operation of each function

TAgen_pred.py

4.2.3. If "*menu-2*" is selected: 1

■ Make TA with daily prediction and fixed clock weights

- This menu calculates the time series of $x_i(t_k)$ day by day.

$$\hat{x}_i(t_k) = x_i(t_{k-1}) + \hat{y}_i(t_{k-1}) \cdot (t_k - t_{k-1}) \quad \text{Eq. (10)}\ ^{*1}$$

$$x_s(t_k) = \sum_i w_i(t_k)\{\hat{x}_i(t_k) - X_{is}(t_k)\} \quad \text{Eq. (9)}\ ^{*1}$$

$$x_i(t_k) = x_s(t_k) + X_{is}(t_k) \quad \text{Eq. (11)}\ ^{*1}$$

※ $x_i(t_k)$: Time difference of ***clock***$_i$ vs TAp is the value to obtain TAp
※ $x_s(t_k)$: The clock with a suffix "s" means the ***Refclk***.
※ t_{k-1} : One day before t_k
※ $X_{is}(t_k)$: Measurement time difference of ***clock***$_i$ vs ***Refclk*** (calculated from the "***UTC(k) – clock***$_i$" data)
※ $\hat{x}_i(t_k)$: Prediction of $x_i(t_k)$
※ $\hat{y}_i(t_{k-1})$: Rate of ***clock***$_i$ (calculated from the past values of x_i) *2
※ $w_i(t_k)$: Weight of ***clock***$_i$ (obtained from the "***clock_file_list.txt***")

```
=====================================
    Menu of the data processing
-------------------------------------
 0.  Plot the "UTC(k)-Clock" data
 1.  Assign the MJD range
 2.  Make TA with daily prediction
         and fixed clock weights
10.  Exit
=====================================
????? Input menu number ? >> 2
```

1

*1 : *Refer to [Ref. 1]*

*2 :

$$\hat{y}_i(t_k) = \frac{x_i(t_k) - x_i(t_k - T_{rate})}{T_{rate}} \quad \text{Eq. (12)}\ ^{*1}$$

T_{rate} *is given by the input value from the console. (p.16).*

4. Operation of each function

TAgen_pred.py

4.2.3. If "*menu-2*" is selected:

■ Outline of the process

" [No.]" are shown in the following pages

#1 Preparation

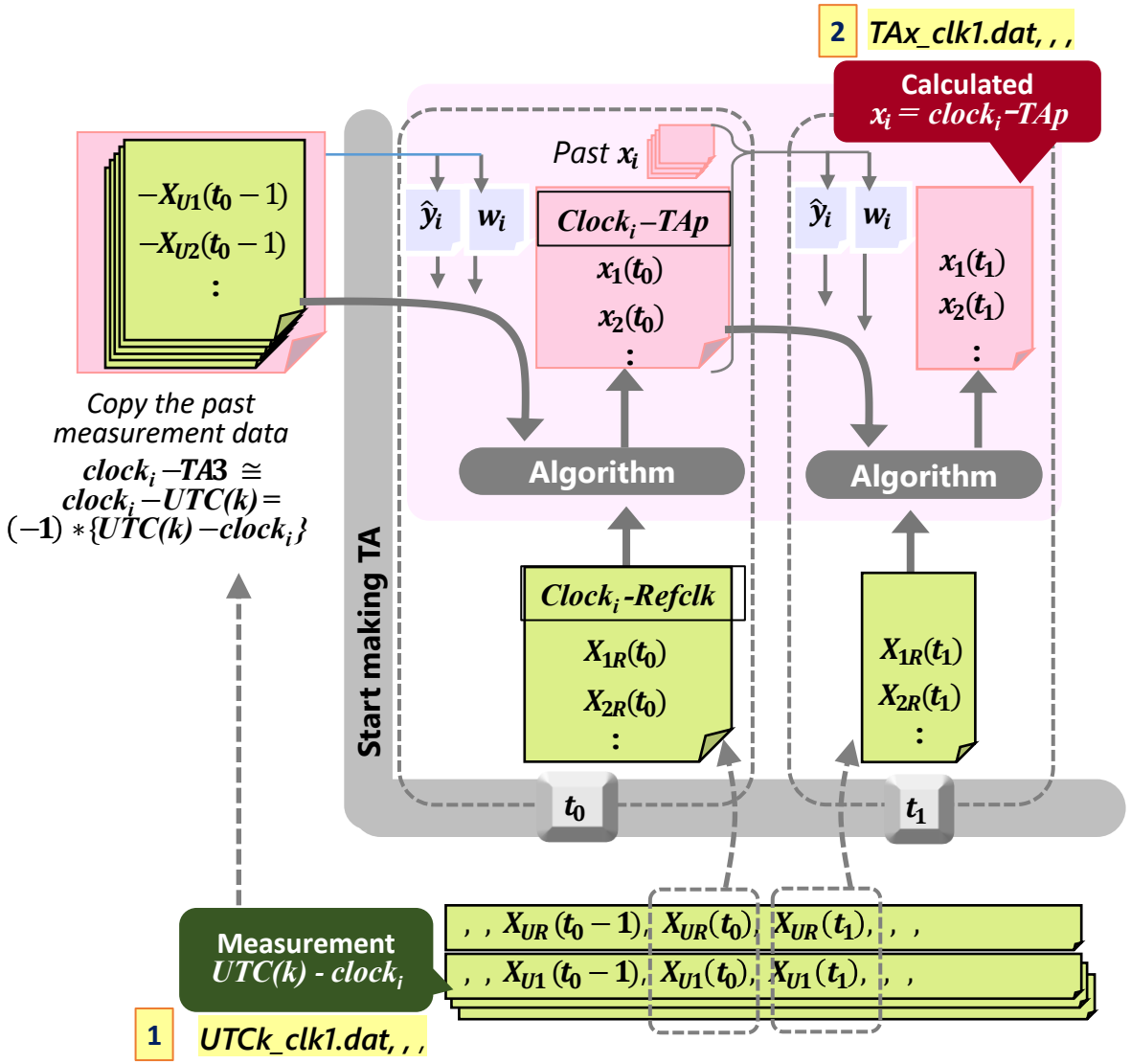
- Take over the parameters and clock data from the results of Initial processing ➔ [1][2][3][4] *(pp.14-15)*
  - Obtain the contents of "***param_list.txt***"
  - Obtain the contents of "***clock_file_list.txt***"
  - Obtain the contents of "***UTCk_(clock$_i$).dat***" 1
  - Obtain the range ***[MJD1, MJD2]***
- Prepare the parameter for rate ➔ [6] *(p.16)*
- Prepare the necessary data set ➔ [5][7] *(p.15,16)*
  - Calculate the "***clock$_i$ – Refclk***" from "***UTC(k) – clock$_i$***".
  - Copy the past "***clock$_i$ – UTC(k)***" into the data file of x_i :

#2 Calculation of daily *TAp*

- Iterative daily calculation ➔ [8] *(pp.17-18)*
  - Set the normalized weights
  - Calculate the prediction $\hat{x}_i$ of each clock
  - Calculated the targeted result x_i : "***TAx_(clock$_i$).dat***" 2

#3 Plotting & saving the results

- Calculate "***UTC(k) – TAp***" for evaluation ➔ [9] *(p.18)*
- Plot and save "***UTC(k) – TAp***" and its *ADEV* ➔ [10][11] *(p.19)*
  - The Result files are saved under "***./TA_RESULT/***".



4. Operation of each function

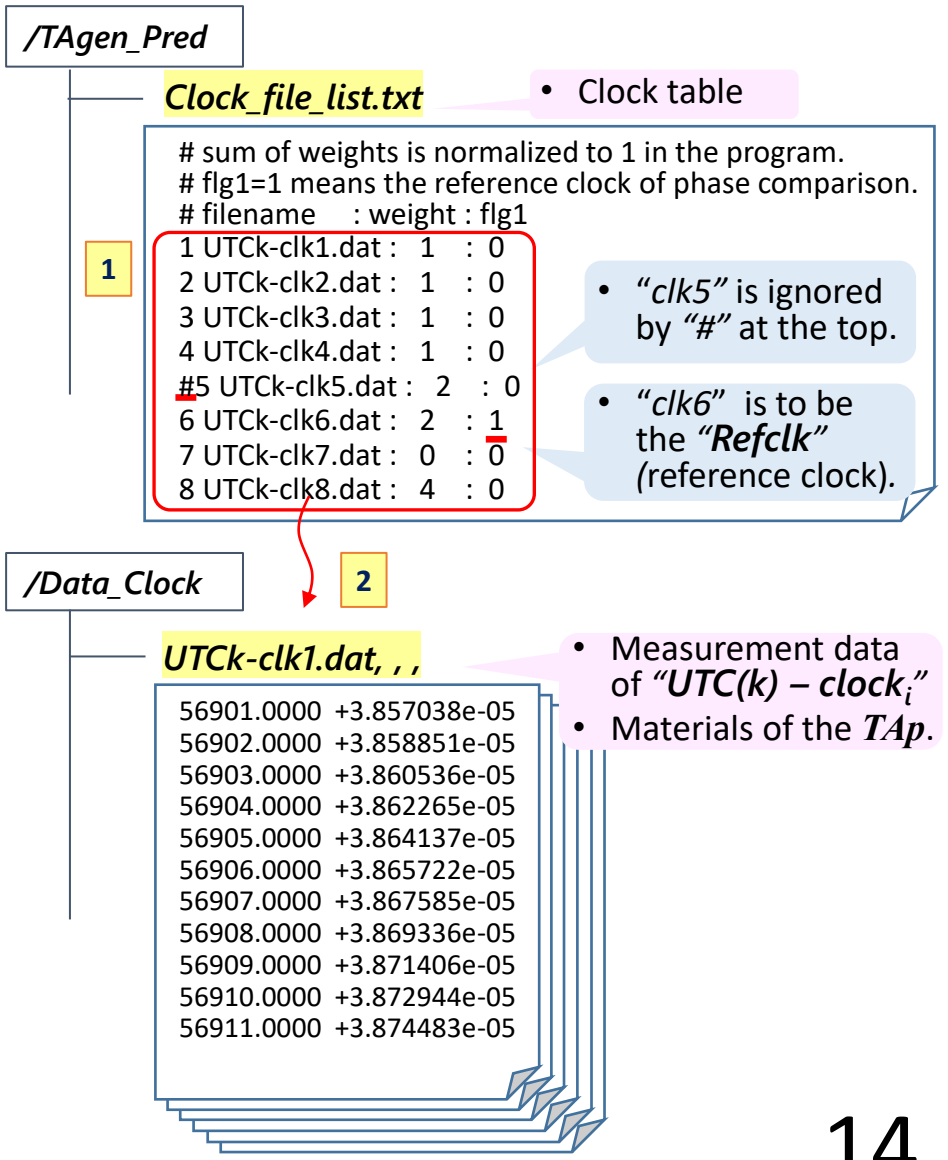
4.2.3. If "*menu-2*" is selected:

■ #1 Preparation

[1] Read the parameters from "*param_list.txt*"
← Initial Processing [1] *(p. 6)*

[2] Read the parameter from "*clock_file_list.txt*" 1
← Initial Processing [2] *(p. 6)*

[3] Read the assigned clock data "*UTCk-(clock$_i$).dat*" 2
← Initial Processing [3] *(p. 6)*



4. Operation of each function

4.2.3. If "*menu-2*" is selected:

■ **#1 Preparation** (Cont.)

[4] Fix the available MJD range ← Initial Processing [4] *(p. 6)*

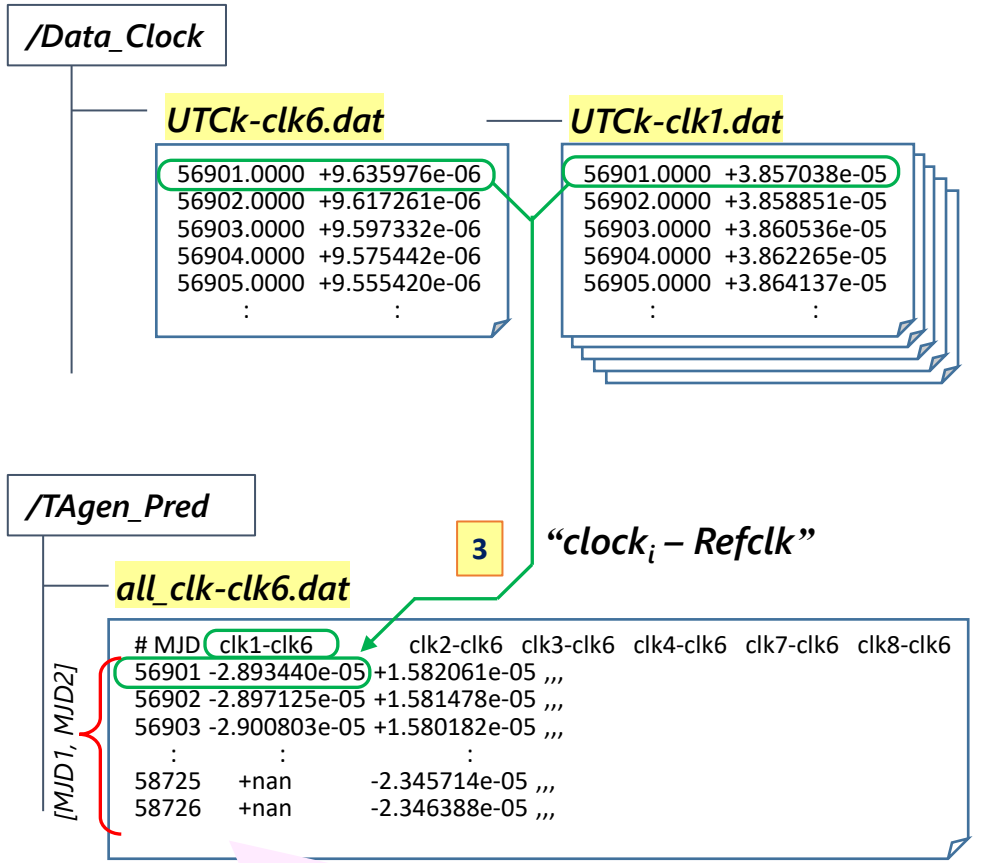
※ If ***[MJD1, MJD2]*** is defined by *"menu-1"* in advance, that range is adopted as a priority.

※ Mathematically, ***TAp*** can be calculated al least one clock. However, concentrating the weight on a single clock reduces the advantages of ***TAp***.

※ To avoid this problem, actual algorithms usually impose restrictions on the maximum weights and minimum number of clocks.

[5] Prepare the measurement data set of $X_{is}(t_k)$

- Calculate the measurement time difference of "***clock$_i$ - Refclk***" from ***"UTCk-(clock$_i$).dat"***. 3
- Results are saved in the file ***"./all_clk-(Refclk).dat"***. *(p. 28)*



- Data file of all "$X_{is}(t_k) = clock_i - clock6$" except for the *clock$_i$* with the mark *"#"* in *"clock_file_list.txt"*

4. Operation of each function

TAgen_pred.py

4.2.3. If "*menu-2*" is selected:

■ #1 Preparation (Cont.)

[6] Enter the parameter T_{rate}, as the span for calculating the rate, from the console

4

- The equation of rate $\hat{y}_i$ is given by *Eq.(12)*. *(p.12)*
- Any value for T_{rate} is permitted within the assigned MJD span.

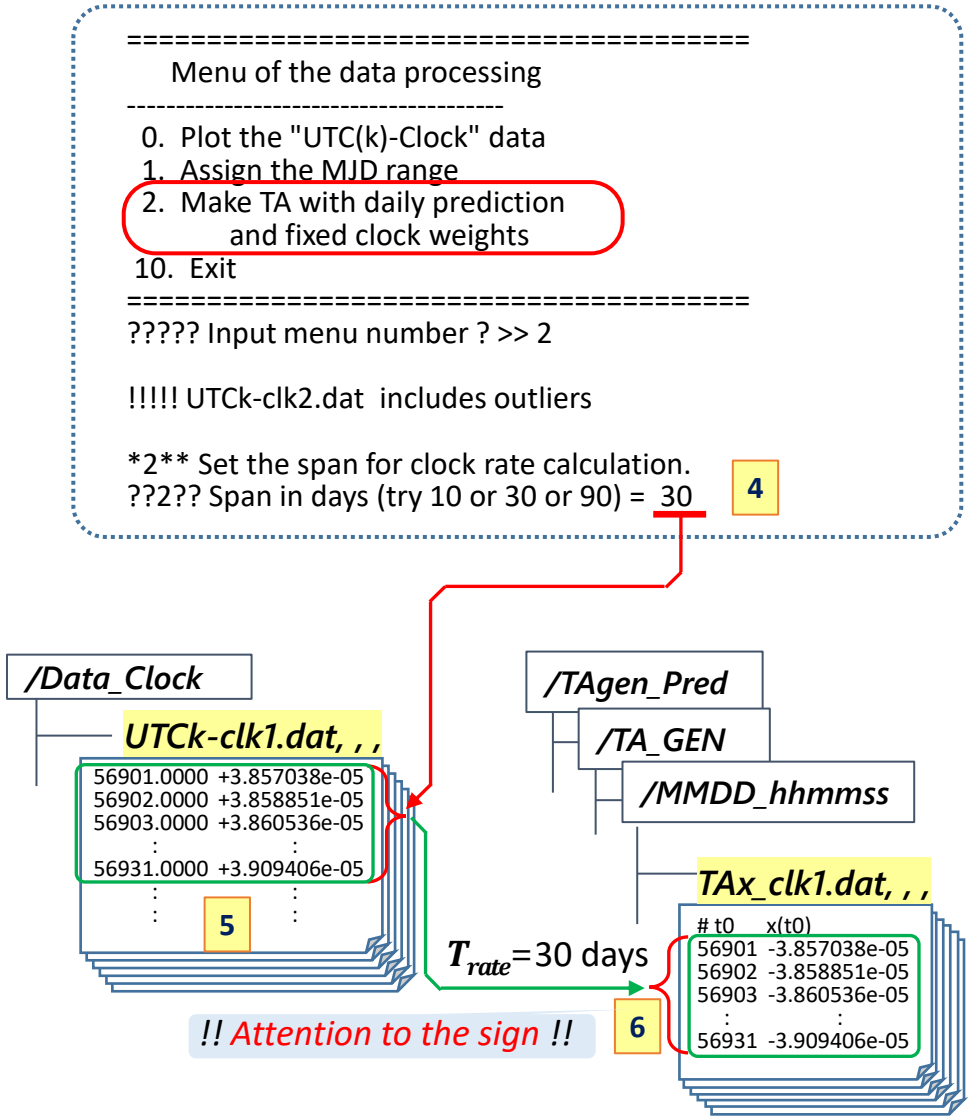
※ The most suitable value is the one that gives the lowest ADEV.
(For a typical commercial Cesium clock, this may be around 30~60 days.)

[7] Prepare the initial data set of x_i in "*TAx_(clock$_i$).dat*" to start the *TAp* calculation

- As shown in *Eq. (10) (p.12)*, the data set of past x_i and $\hat{y}_i$ values are required to start the *TAp* calculation. In particular, $\hat{y}_i$ needs the x_i over the latest T_{rate} days.
- As no past x_i are at the beginning, "***UTC(k) – clock$_i$***" data is used as a substitute for the initial x_i. 5

$$clock_i(t) - UTC(k)(t) \rightarrow clock_i(t) - TAp(t) \equiv x_i(t) \quad (t < \text{start date})$$

- This "***clock$_i$ – UTC(k)***" data within the latest past T_{rate} range are copied in "***TAx_(clock$_i$).dat***". *(p.30)* 6



4. Operation of each function

TAgen_pred.py

4.2.3. If "*menu-2*" is selected:

■ #2 Calculation of daily TAp

[8] Calculate $x_i(t_k)$ for "$TA_0 \le t_k \le MJD2$"

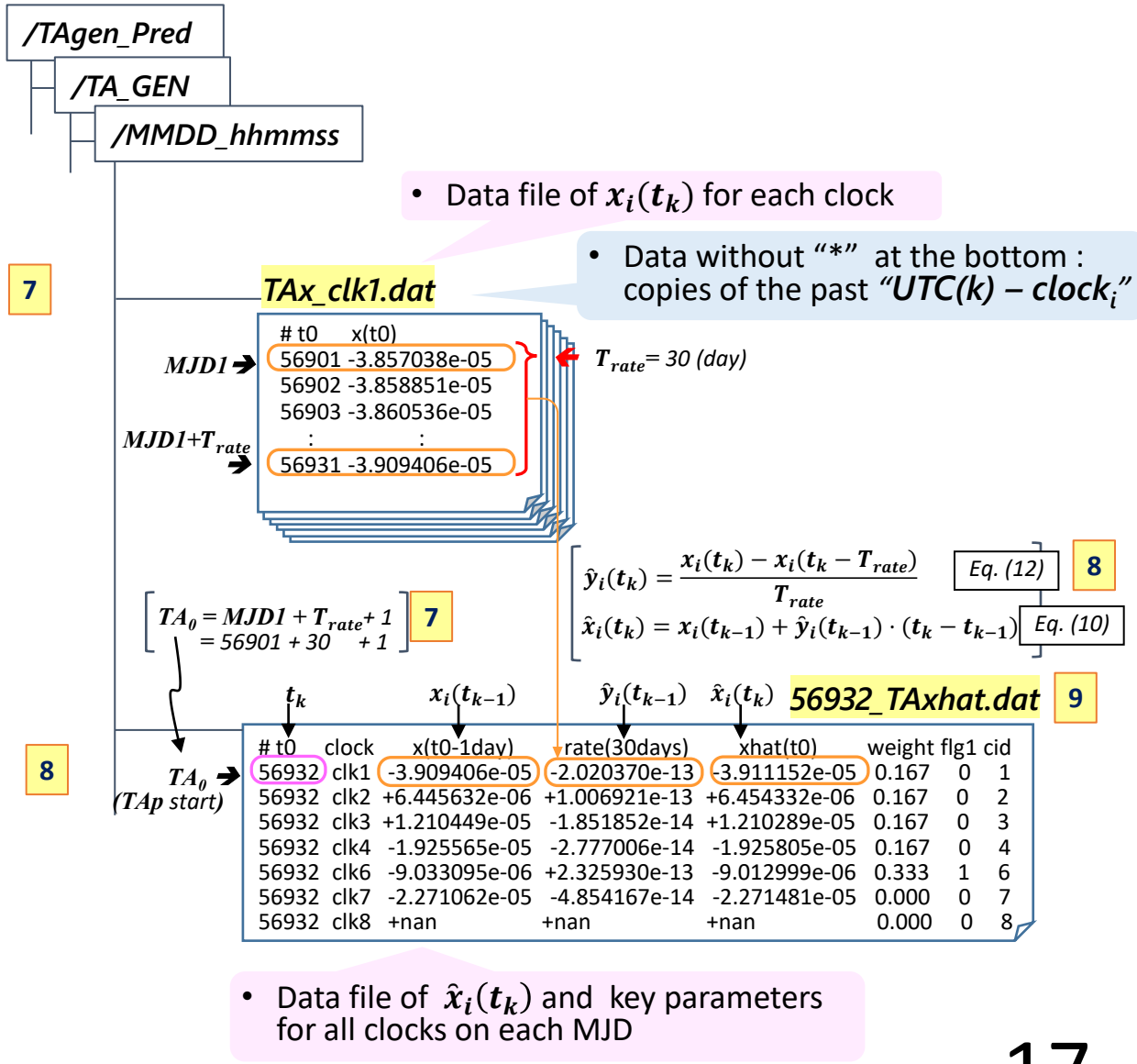
- The TAp calculation start date is "$TA_0 = MJD1 + T_{rate} + 1$".

[8.1] Set the weights for the available clocks

- The given initial weights in "***clock_file_list.txt***" *(p.25)* are used after normalization.
- If the measurement data for a clock is not normal (missing or outlier), the weight of this clock becomes zero for the date.

[8.2] Calculate the prediction $\hat{x}_i(t_k)$

- $\hat{x}_i(t_k)$ is calculated by *Eq.(10) (p.12)* using the past x_i.
- $\hat{y}_i(t_{k-1})$ is calculated by *Eq.(12) (p.12)* as the slope of x_i over the latest past T_{rate} period.
- The daily calculated results are saved in the files "***(MJD)_TAxhat.dat***". *(p.29)* 9



4. Operation of each function

TAgen_pred.py

4.2.3. If "*menu-2*" is selected:

■ #2 Calculation of daily TAp (Cont.)

[8] Calculate $x_i(t_k)$ for "$TA_0 \le t_k \le MJD2$" (Cont.)

[8.3] Calculate the daily $x_i(t_k)$

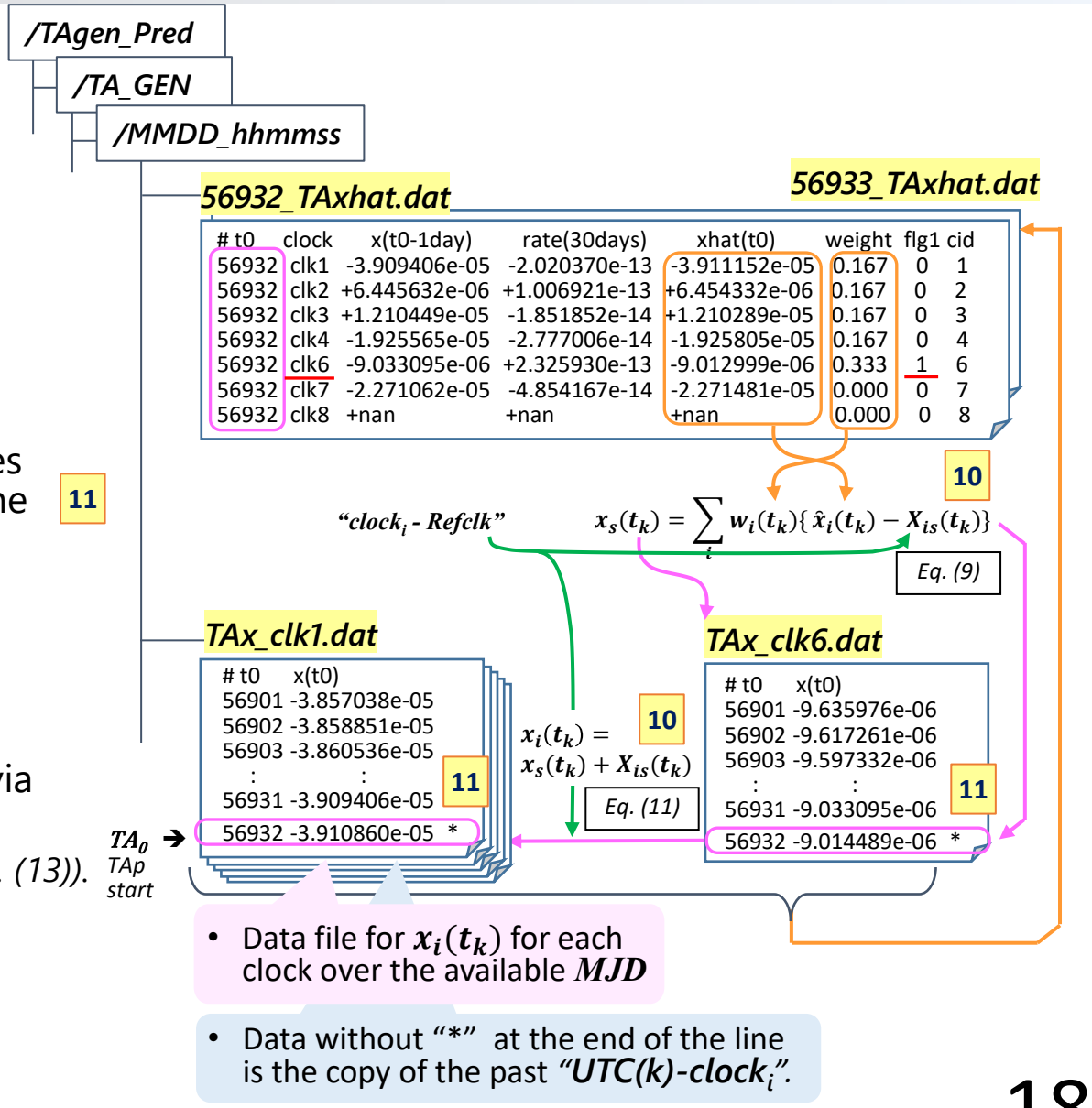
- Calculate $x_i(t_k)$ of each clock by *Eq. (9)(11) (p.12).* 10
- The calculated time series of $x_i(t_k)$ are saved in the files "***TAx_(clock$_i$).dat*** with the star mark "*****" at the end of the line. *(p.30)* 11

■ #3 Plotting & saving the results

[9] Calculate "*UTC(k)-TAp*" for evaluation

- TAp can be compared with other timescales or clocks via common reference, for example ***UTC(k)***.
- "***UTC(k) – TAp***" is obtained as follows *(Refer to [Ref. 2] Eq. (13)).*

$$UTC(k) - TAp = \underbrace{[UTC(k) - h_i]}_{\text{"UTCk-(clock}_i\text{).dat"}} + \underbrace{[h_i - TAp]}_{\text{Calculated } x_i} \quad \text{Eq. (13)}$$



4. Operation of each function

TAgen_pred.py

4.2.3. If "*menu-2*" is selected:

■ #3 Plotting & saving the results (Cont.)

[10] Plot the results 12

- Left : time difference vs ***UTC(k)*** *(p.37)*
- Middle : *ADEV*s of left data *(p.37)*
- Right : clock weights *(p.38)*

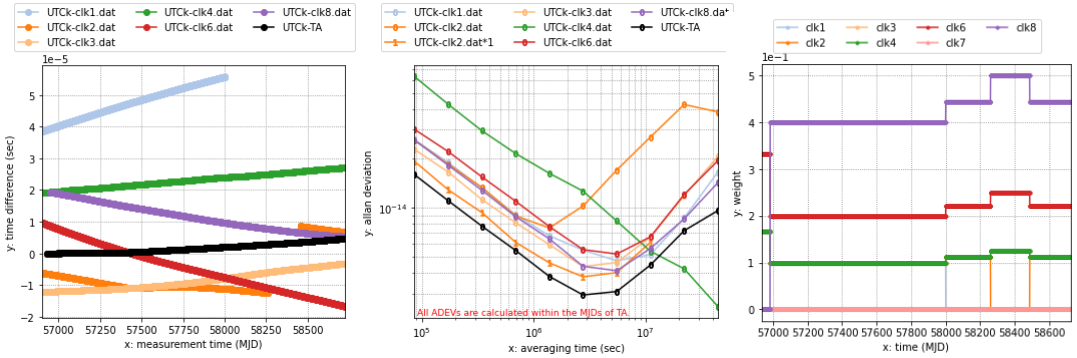
[11] Save the results, if required 13

- Results are saved at ***"./TA_RESULT/(time)/".*** *(pp.32-38)*

- ***Log_(time).txt*** : history of the process
- ***fig _(time).pdf*** : figure of "***UTC(k) – clock$_i$***" & *ADEV*
  all_raw_clk_TA_(time).dat : time difference vs ***UTC(k)***
- ***all_adev_(time).dat*** : *ADEV* of "***UTC(k) – clock$_i$***"
- ***all_weight_(time).dat*** : daily calculated weights
- ***wgt_fig_(time).dat*** : figure of all weights

```
????? Span in days (try 10 or 30 or 90) =  30

***** Calculating an timescale for  56932
                    :
***** Calculating an timescale for  58726
```

12




```
**2** make a timescale with prediction *****

????? Save figure? (y/n) = y
```

13

```
::::: save logfile =  ./TA_RESULT/0731_155524/log_0731_155524.txt
::::: save figfile =  ./TA_RESULT/0731_155524/fig_0731_155524.pdf
::::: save alldata =  ./TA_RESULT/0731_155524/all_raw_clk_TA_0731_155524.dat
::::: save ADEVdat =  ./TA_RESULT/0731_155524/all_adev_0731_155524.dat
::::: save weights =  ./TA_RESULT/0731_155524/all_weight_0731_155524.dat
::::: save wgt_fig =  ./TA_RESULT/0731_155524/wgt_fig_0731_155524.pdf

=======================================
    Menu of the data processing
---------------------------------------
 0.  Plot the "UTC(k)-Clock" data
 1.  Assign the MJD range
 2.  Make TA with daily prediction
         and fixed clock weights
 10.  Exit
=======================================
????? Input menu number ? >>
```

4. Operation of each function

TAgen_pred.py

4.2.3. If "*menu-2*" is selected:

Pytool_TAgen/TAgen_Pred/TA_RESULT/0731_155524/

all_raw_clk_TA_0731_155524.dat

fname	UTCk-clk1.dat	UTCk-clk2.dat	UTCk-clk3.dat	UTCk-clk4.dat	UTCk-clk6.dat	UTCk-clk7.dat	UTCk-clk8.dat	UTCk-TA
weight	1.0	1.0	1.0	1.0	2.0	0.0	4.0	0.0
flag	0	0	0	0	1	0	0	3
cid	1	2	3	4	6	7	8	0
56901	+3.857038e-05	-6.184638e-06	-1.215249e-05	+1.918367e-05	+9.635976e-06	+2.258480e-05	+nan	+nan
:	:	:	:	:	:	:	:	:
56931	+3.909406e-05	-6.445632e-06	-1.210449e-05	+1.925565e-05	+9.033095e-06	+2.271062e-05	+nan	+nan
56932	+3.910934e-05	-6.452386e-06	-1.210189e-05	+1.925726e-05	+9.015229e-06	+2.271663e-05	+nan	+7.400889e-10
:	:	:	:	:	:	:	:	:
58726	+nan	+6.687379e-06	-3.180825e-06	+2.708426e-05	-1.677650e-05	+4.442301e-05	+5.270004e-06	+4.684945e-06

TAp calculation starts from $MJD1 + T_{rate} + 1 = 56901 + 30 + 1$

all_weight_0731_155524.dat

# MJD	clk1	clk2	clk3	clk4	clk6	clk7	clk8
56932.0	0.167	0.167	0.167	0.167	0.333	0.000	0.000
:	:	:	:	:	:	:	:
56983.0	0.100	0.100	0.100	0.100	0.200	0.000	0.400
:	:	:	:	:	:	:	:
58001.0	0.000	0.111	0.111	0.111	0.222	0.000	0.444
:	:	:	:	:	:	:	:
58261.0	0.000	0.000	0.125	0.125	0.250	0.000	0.500
:	:	:	:	:	:	:	:
58488.0	0.000	0.111	0.111	0.111	0.222	0.000	0.444
:	:	:	:	:	:	:	:
58726.0	0.000	0.111	0.111	0.111	0.222	0.000	0.444

*Each weight is normalized to be proportional to the initial value in the "**clock_filet_list.txt**".*

The reason of zero weight:
- *Initial setting*
- *Missing of clock data*
- *Anomaly of clock data*

wgt_fig_0731_155524.pdf

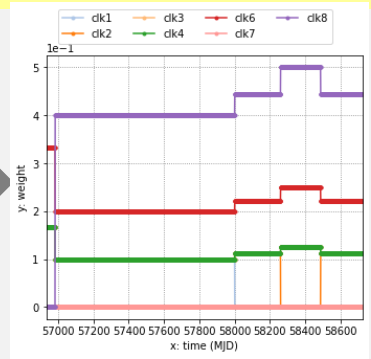
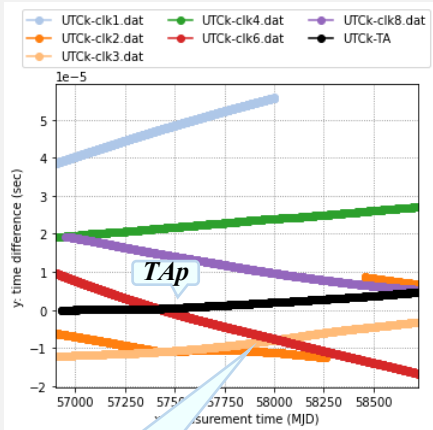
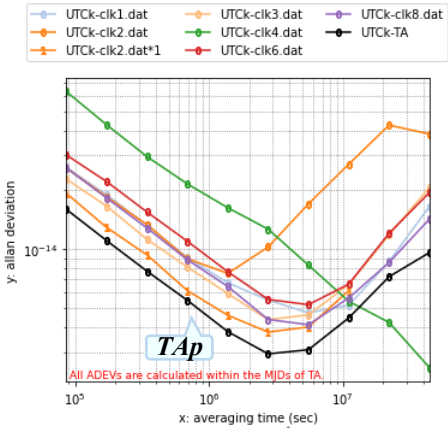


fig_0731_155524.pdf





"UTCk-clk2.dat" is divided two blocks before/after the anomalies.

log_0731_155524.txt

```
# Data log at 2025.07.31_15h55m_24s
#
**0** Read and plot initial clock data and Allan deviation*****
::::: Input clocklist   : clock_file_list.txt
::::: Input clock file  : ['UTCk-clk1.dat', 'UTCk-clk2.dat', 'UTCk-clk3.dat', 'UTCk-clk4.dat', 'UTCk-clk6.dat', 'UTCk-clk7.dat', 'UTCk-clk8.dat']
::::: data time interval (t_intval): 86400(sec)
::::: Outlier limit (x_limit))     : 1000.0

**2** make a timescale with predicton *****
::::: saved TAxhat data : ./TA_GEN/0731_155500/(MJD)_TAxhat.dat
::::: saved TAx data : ./TA_GEN/0731_155500/TAx_(clock).dat
::::: interval for rate estimation (TArate_span)     : 30(days)
```

all_adev_0731_155524.dat

Tau(s)	UTCk-clk1.dat	UTCk-clk2.dat	UTCk-clk2.dat*1	UTCk-clk3.dat	UTCk-clk4.dat	UTCk-clk6.dat	UTCk-clk8.dat	UTCk-TA
MJDspan	56932-58000	56932-58260	58457-58726	56932-58726	56932-58726	56932-58726	56952-58726	56932-58726
86400	+2.593622e-14	+2.572997e-14	+1.914455e-14	+2.260179e-14	+6.282088e-14	+2.997311e-14	+2.576366e-14	+1.587481e-14
172800	+1.879802e-14	+1.838375e-14	+1.284166e-14	+1.647945e-14	+4.260514e-14	+2.195515e-14	+1.811728e-14	+1.101474e-14
345600	+1.319901e-14	+1.328139e-14	+9.326690e-15	+1.119268e-14	+2.939305e-14	+1.538963e-14	+1.275807e-14	+7.711257e-15
691200	+9.041313e-15	+8.935562e-15	+6.149651e-15	+8.095952e-15	+2.137947e-14	+1.094094e-14	+8.814858e-15	+5.487931e-15
1382400	+6.738033e-15	+7.521008e-15	+4.614288e-15	+5.952914e-15	+1.619558e-14	+7.670694e-15	+6.457422e-15	+3.810020e-15
2764800	+5.508946e-15	+1.023444e-14	+3.789893e-15	+4.377554e-15	+1.260711e-14	+5.552367e-15	+4.391604e-15	+2.938859e-15
5529600	+4.747165e-15	+1.694716e-14	+4.020702e-15	+4.635671e-15	+8.287096e-15	+5.218094e-15	+4.131121e-15	+3.084185e-15
11059200	+5.182775e-15	+2.695475e-14	+6.159347e-15	+6.611689e-15	+5.426419e-15	+6.643764e-15	+5.645967e-15	+4.474511e-15
22118400	+8.639638e-15	+4.250378e-14	+nan	+1.179217e-14	+4.242674e-15	+1.202004e-14	+8.546454e-15	+7.239207e-15
44236800	+1.646562e-14	+3.832687e-14	+nan	+2.051915e-14	+2.502899e-15	+1.933946e-14	+1.418509e-14	+9.593108e-15

***MJDspan** is the period used in the ADEV calculation.*

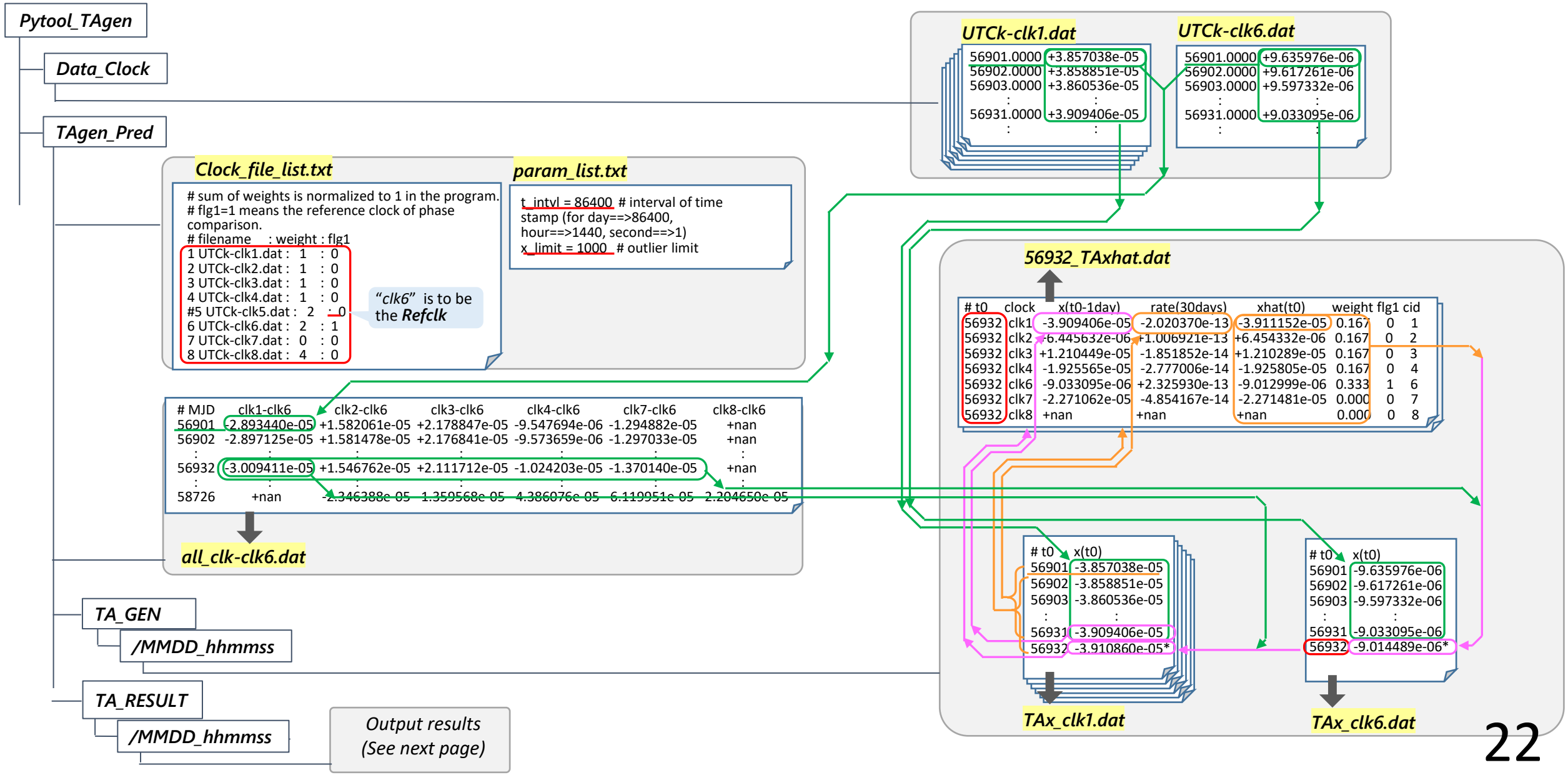
*If there are not sufficient samples, ADEV cannot be calculated, and is expressed as "**nan**".*

A-1. Input / Output files :

A-1.1. Relation of the files

A-1.1. Relation of the files (1)

TAgen_pred.py



A-1.1. Relation of the files (2)

TAgen_pred.py

Pytool_TAgen/TAgen_Pred/TA_RESULT/0731_155524/

Clock_file_list.txt

```
# sum of weights is normalized
to 1 in the program.
# flg1=1 means the reference
clock of phase comparison.
# filename    : weight : flg1
1 UTCk-clk1.dat :  1   : 0
2 UTCk-clk2.dat :  1   : 0
3 UTCk-clk3.dat :  1   : 0
4 UTCk-clk4.dat :  1   : 0
#5 UTCk-clk5.dat :  2   : 0
6 UTCk-clk6.dat :  2   : 1
7 UTCk-clk7.dat :  0   : 0
8 UTCk-clk8.dat :  4   : 0
```

UTCk-clk1.dat

```
56901.0000 +3.857038e-05
56902.0000 +3.858851e-05
     :          :
57999.0000 +5.576701e-05
58000.0000 +5.578885e-05
```

all_raw_clk_TA_0731_155524.dat

fname	UTCk-clk1.dat	UTCk-clk2.dat	UTCk-clk3.dat	UTCk-clk4.dat	UTCk-clk6.dat	UTCk-clk7.dat	UTCk-clk8.dat	UTCk-TA
Weight	1.0	1.0	1.0	1.0	2.0	0.0	4.0	0.0
flag	0	0	0	0	1	0	0	3
cid	1	2	3	4	6	7	8	0
56901	+3.857038e-05	-6.184638e-06	-1.215249e-05	+1.918367e-05	+9.635976e-06	+2.258480e-05	+nan	+nan
:	:	:	:	:	:	:	:	:
56931	+3.909406e-05	-6.445632e-06	-1.210449e-05	+1.925565e-05	+9.033095e-06	+2.271062e-05	+nan	+nan
56932	+3.910934e-05	-6.452386e-06	-1.210189e-05	+1.925726e-05	+9.015229e-06	+2.271663e-05	+nan	+7.400889e-10
:	:	:	:	:	:	:	:	:
58726	+nan	+6.687379e-06	-3.180825e-06	+2.708426e-05	-1.677650e-05	+4.442301e-05	+5.270004e-06	+4.684945e-06

all_adev_0731_155524.dat

Tau(s)	UTCk-clk1.dat	UTCk-clk2.dat	UTCk-clk2.dat*1	UTCk-clk3.dat	UTCk-clk4.dat	UTCk-clk6.dat	UTCk-clk8.dat	UTCk-TA
MJDspan	56932-58000	56932-58260	58457-58726	56932-58726	56932-58726	56932-58726	56952-58726	56932-58726
86400	+2.593622e-14	+2.572997e-14	+1.914455e-14	+2.260179e-14	+6.282088e-14	+2.997311e-14	+2.576366e-14	+1.587481e-14
172800	+1.879802e-14	+1.838375e-14	+1.284166e-14	+1.647945e-14	+4.260514e-14	+2.195515e-14	+1.811728e-14	+1.101474e-14
:	:	:	:	:	:	:	:	:
11059200	+5.182775e-15	+2.695475e-14	+6.159347e-15	+6.611689e-15	+5.426419e-15	+6.643764e-15	+5.645967e-15	+4.474511e-15
22118400	+8.639638e-15	+4.250378e-14	+nan	+1.179217e-14	+4.242674e-15	+1.202004e-14	+8.546454e-15	+7.239207e-15
44236800	+1.646562e-14	+3.832687e-14	+nan	+2.051915e-14	+2.502899e-15	+1.933946e-14	+1.418509e-14	+9.593108e-15

log_0731_155524.txt

```
# Data log at 2025.07.31_15h55m_24s
#
**0** Read and plot initial clock data and Allan deviation*****
::::: Input clocklist   : clock_file_list.txt
::::: Input clock file  : ['UTCk-clk1.dat', 'UTCk-clk2.dat', 'UTCk-clk3.dat', 'UTCk-
clk4.dat', 'UTCk-clk6.dat', 'UTCk-clk7.dat', 'UTCk-clk8.dat']
::::: data time interval (t_intval): 86400(sec)
::::: Outlier limit (x_limit))     : 1000.0

**2** make a timescale with predicton *****
::::: saved TAxhat data : ./TA_GEN/0731_155500/(MJD)_TAxhat.dat
::::: saved TAx data : ./TA_GEN/0731_155500/TAx_(clock).dat
::::: interval for rate estimation (TArate_span)     : 30(days)
```

all_weight_0731_155524.dat

# MJD	clk1	clk2	clk3	clk4	clk6	clk7	clk8
56932.0	0.167	0.167	0.167	0.167	0.333	0.000	0.000
:	:	:	:	:	:	:	:
56983.0	0.100	0.100	0.100	0.100	0.200	0.000	0.400
:	:	:	:	:	:	:	:
58001.0	0.000	0.111	0.111	0.111	0.222	0.000	0.444
:	:	:	:	:	:	:	:
58261.0	0.000	0.000	0.125	0.125	0.250	0.000	0.500
:	:	:	:	:	:	:	:
58488.0	0.000	0.111	0.111	0.111	0.222	0.000	0.444
:	:	:	:	:	:	:	:
58726.0	0.000	0.111	0.111	0.111	0.222	0.000	0.444

wgt_fig_0731_155524.pdf

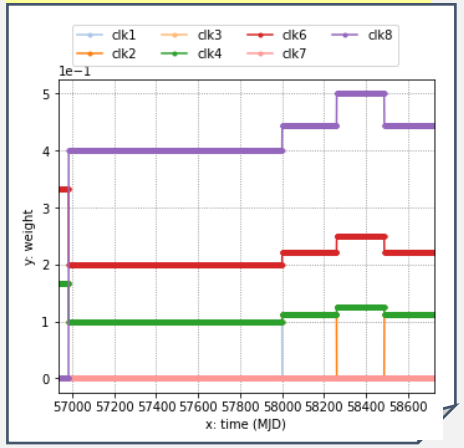
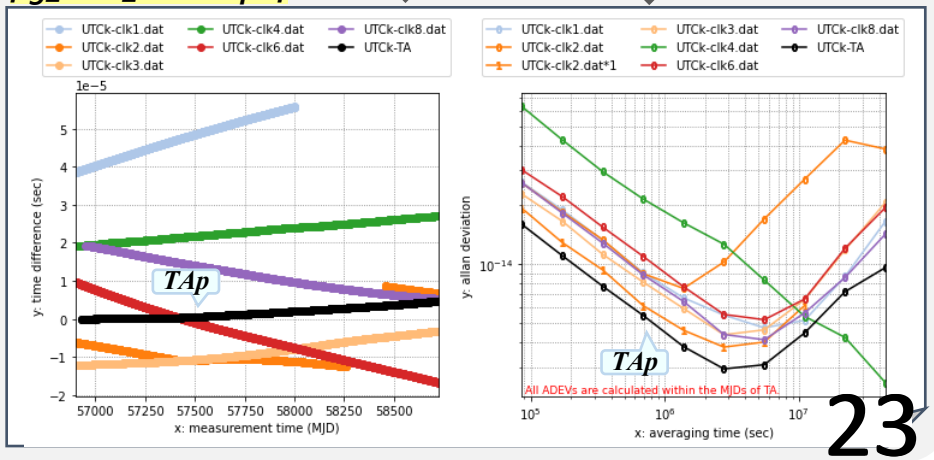


fig_0731_155524.pdf

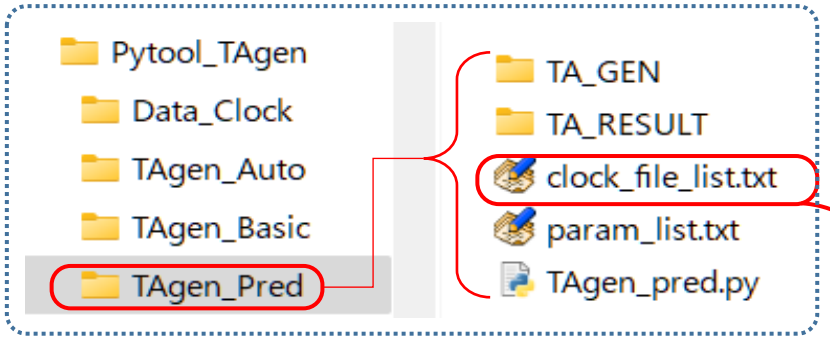


A-1. Input / Output files :

A-1.2. Files used in the calculation

A-1.2.1 *"clock_fie_list.txt"*

■ *"/Pytool_TAgen/TAgen_Pred/**clock_file_list.txt**"*



Outline

- "***clock_file_list.txt***" provides the conditions of each clock in the averaging process.
- This table should be prepared in advance.

Details / Rules of use

- The line starting with "#" is ignored. 1

- 1st column : file No. (defines plot color)
- 2nd column : data file name
- 3rd column : clock weight*1
- 4th column : flag of the reference clock *2.

Note

*1 : Each weight is normalized in the program. 2

*2 : The clock with *"**flg1=1**"*, the reference clock named as "***Refclk***" hereafter, is used as the base clock to get the time difference between clocks. 3

```
# sum of weights is normalized to 1 in the program.
# flg1=1 means the reference clock of phase comparison.
# filename     : weight : flg1
1 UTCk-clk1.dat :  1  : 0
2 UTCk-clk2.dat :  1  : 0
3 UTCk-clk3.dat :  1  : 0
4 UTCk-clk4.dat :  1  : 0
#5 UTCk-clk5.dat :  2  : 0
6 UTCk-clk6.dat :  2  : 1
7 UTCk-clk7.dat :  0  : 0
8 UTCk-clk8.dat :  4  : 0
```

1

- ***clk5*** is ignored by "#".

2

- ***clk5*** *is ignored from all the calculation*
- ***clk7*** *is excluded from the averaging*

3

- ***clk6*** is to be the ***Refclk*** *(*reference clock*)*.

A-1.2.2 *"param_list.txt"*

■ *"/Pytool_TAgen/TAgen_Pred/**param_list.txt**"*

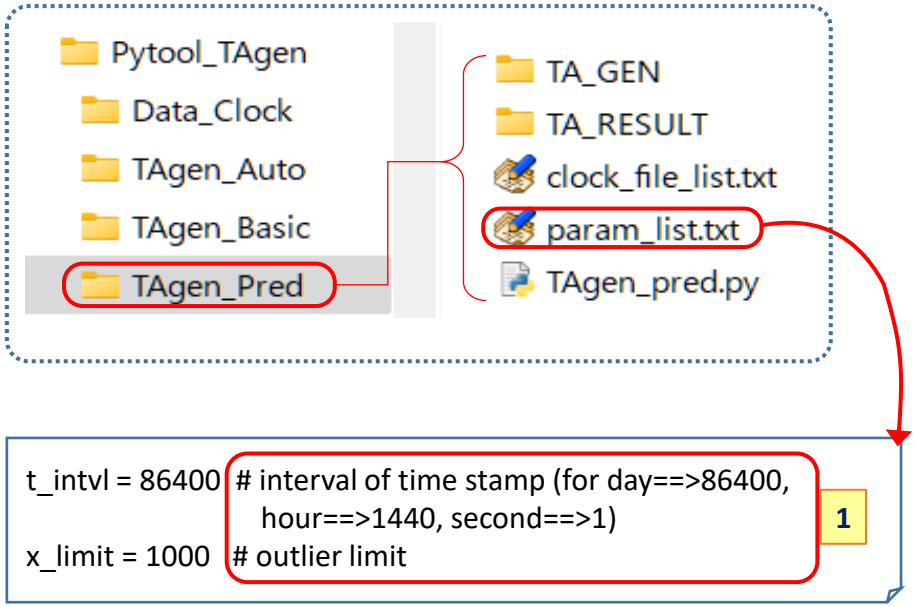
Outline

- *"**param_list.txt**"* provides the parameters for the ***TAp*** calculation.
- Parameters that are fixed within the program but can be changed on demand are stored here.
- This table should be prepared in advance.

Details / Rules of use

- These parameters are used with the same names in the program.
- The text after "#" provides the explanation of the parameter. 1

- ***t_intvl*** : interval of time stamp
  (for day → *86400*, hour → *1440*, second → *1*)
- ***x_limit*** : outlier limit



A-1.2.3 *"UTCk_(clock$_i$).dat"*

■ *"/Pytool_TAgen/Data_Clock/**UTCk-(clock$_i$).dat**"*

Outline

- *"**UTCk-(clock$_i$).dat**"* are the measurement clock data as the materials of ***TAp*** calculation.
- This data files should be prepared in advance.

Details / Rules of use

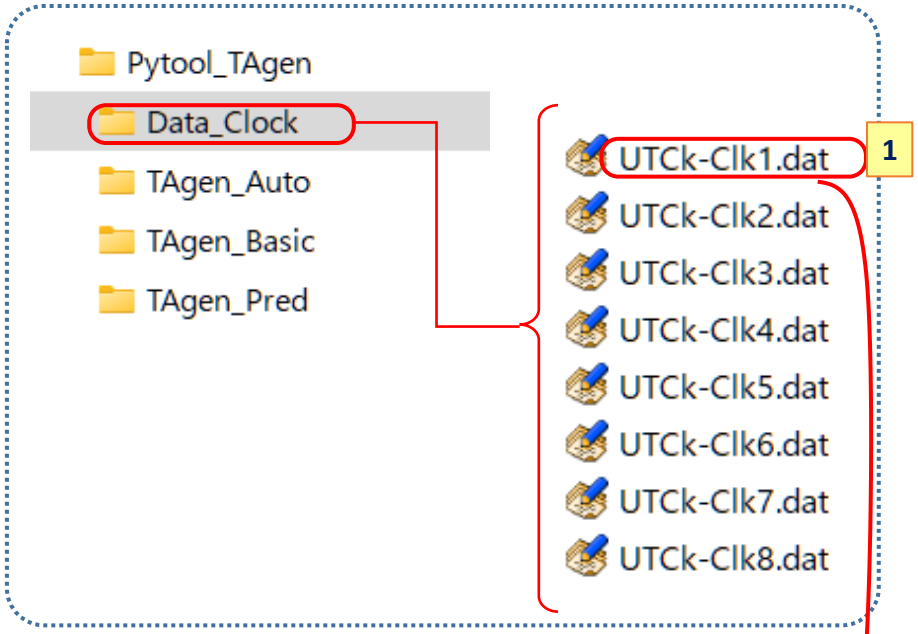
- One file contains data from a single clock.
- The file name should be *"**UTCk-****.dat**"*, where the four characters "********" identify each clock. 1
- 1st column : observation time stamp 2
- 2nd column : measured time difference of *"**UTC(k) – clock$_i$**"* (in second) 3

Note

※ The Interval of the 1st column should be specified as ***t_intvl*** in *"**param_list.txt**"*. *(p.26)* 4

※ This sampling interval must be constant and continuous.

※ Sufficient data is required for each clock to start the calculation. *(p.16)*



A-1.2.4 *"all_clk_(Refclk).dat"*

■ *"/Pytool_TAgen /TAgen_Pred/**all_clk_(Refclk).dat**"*

Outline

- *"**all_clk_(Refclk).dat**"* is the merged data of time difference *"**clock$_i$ – Refclk**"* calculated from the *"**UTCk-(clock$_i$).dat**"* files.
- This file is an intermediate product during *"menu-2"*.

Details / Rules of use

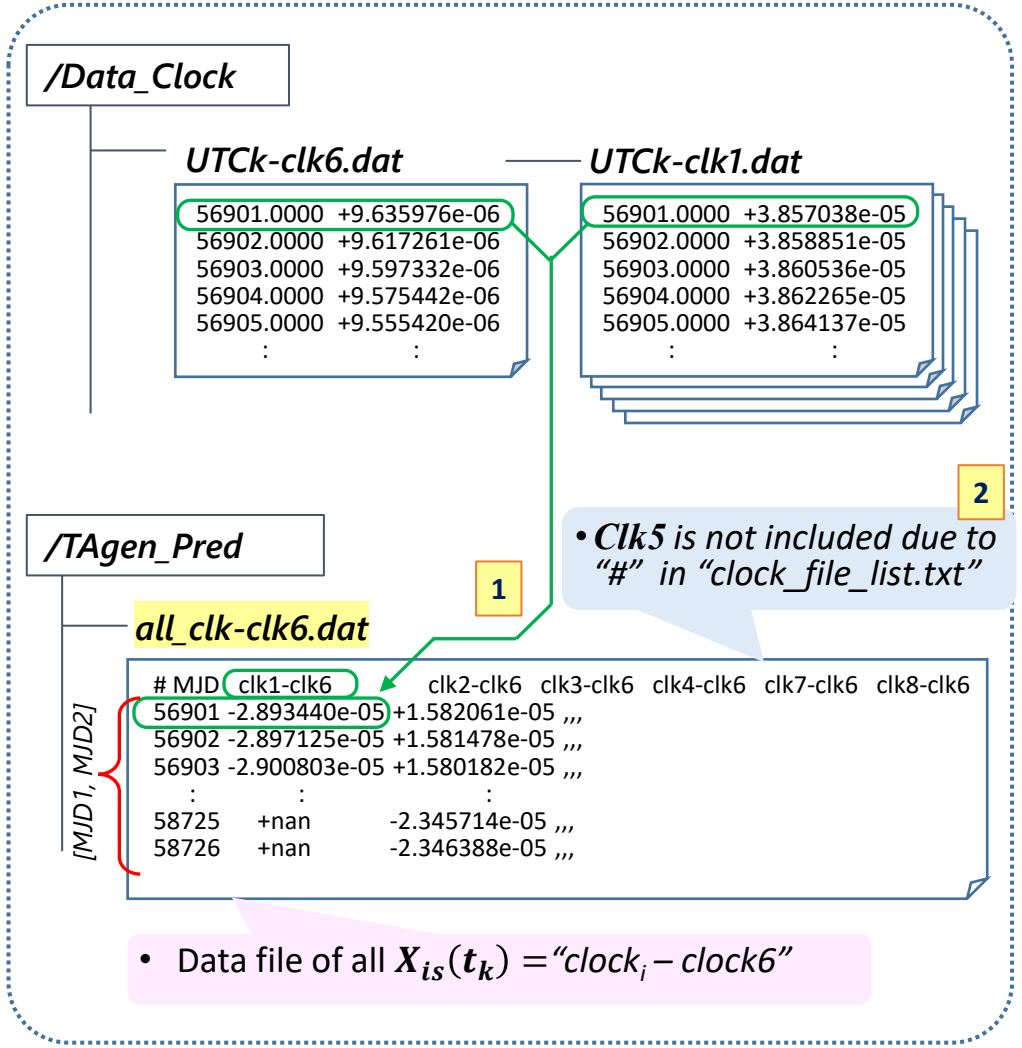
- ***Refclk*** is assigned by the flg1 in *"**clock_file_list.txt**"*.

- 1st column : observation time stamp
- 2nd column : measured time difference of *"**clock$_i$ – Refclk**"* 1

:

Note

※ The clock with "#" in *"**clock_file_list.txt**"* is excluded. *(p.25)* 2



A-1.2.5 *"(MJD)_TAxhat.dat"*

■ *"/Pytool_TAgen/TAgen_Pred/TA_GEN/(time)/(MJD)_TAxhat.dat"*

Outline

- *"(MJD)_TAxhat.dat"* is the intermediate product for checking the ***TAp*** calculation. The main result is $\hat{x}_i(t_k)$.
- These data are intermediate products during *"menu-2"* : one file is for one day result.

Details / Rules of use

1

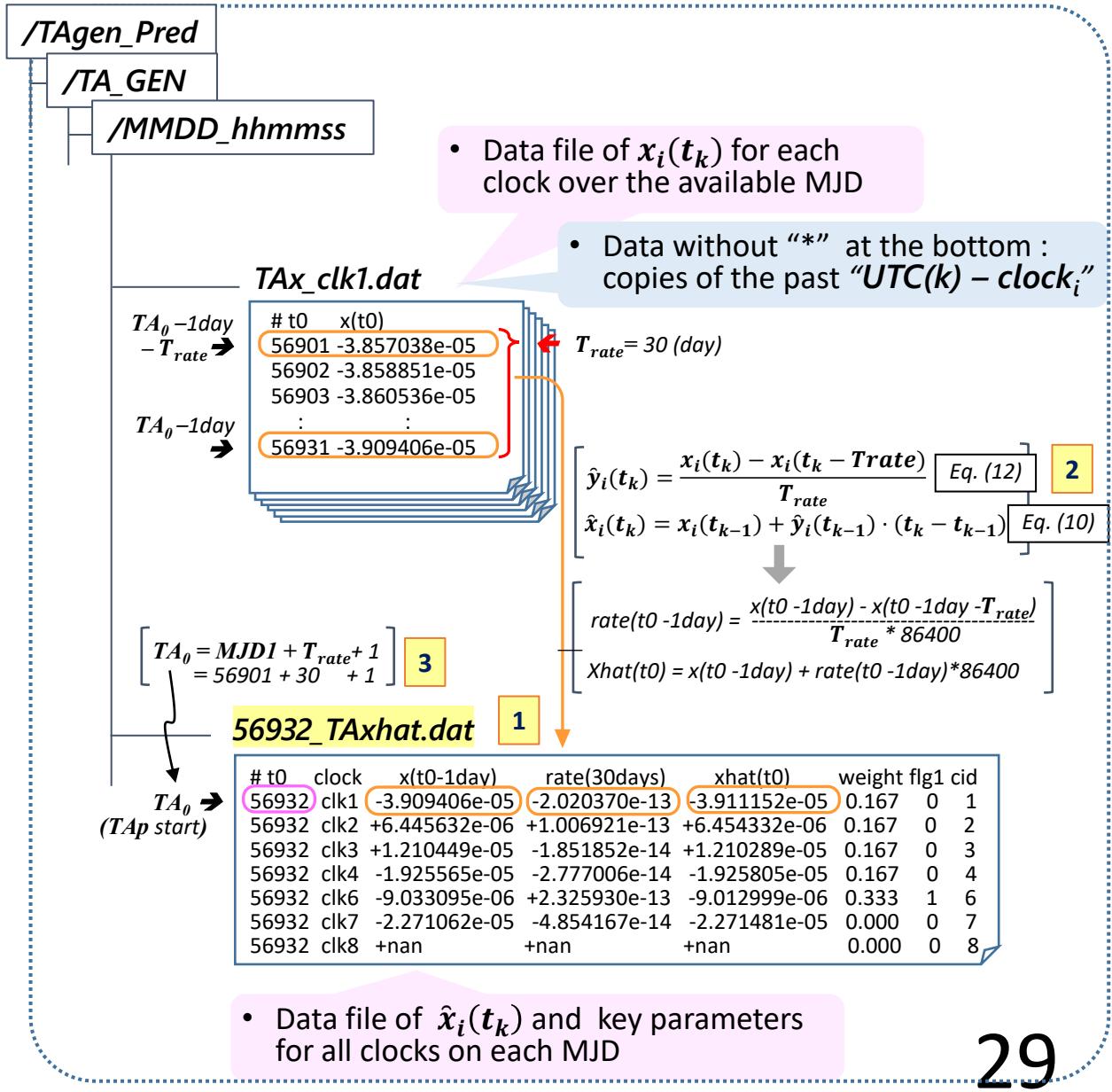
- 1st column : t_k: MJD to determine ***TAp***
- 2nd column : clock name
- 3rd column : $x_i(t_{k-1})$: x_i on the previous day of t_k
- 4th column : $\hat{y}_i(t_{k-1})$ *(Eq. (12) on p.12)*
- 5th column : $\hat{x}_i(t_k)$ *(Eq. (10), on p.12)*
- 6th column : normalized clock weight 2
- 7th column : ***flg1***
- 8th column : clock ID

Note

※ T_{rate} is given from the console at *"menu-2"*.

※ The ***TAp*** start date is determined by *"$TA_0 = MJD1 + T_{rate} + 1$". (p.17)* 3

※ ***MJD1*** is the oldest *MJD* when the available clock data is provided, or is specified by *"menu-1"*.



A-1.2.6 "*TAx_(clock$_i$).dat*"

TAgen_pred.py

■ "*/Pytool_TAgen/TAgen_Pred/TA_GEN/(time)/**TAx_(clock$_i$).dat***"

Outline

- "***TAx_(clock$_i$).dat***" is the time series of x_i of *clock$_i$* which is the targeted product of ***TAp*** calculation.

Details / Rules of use

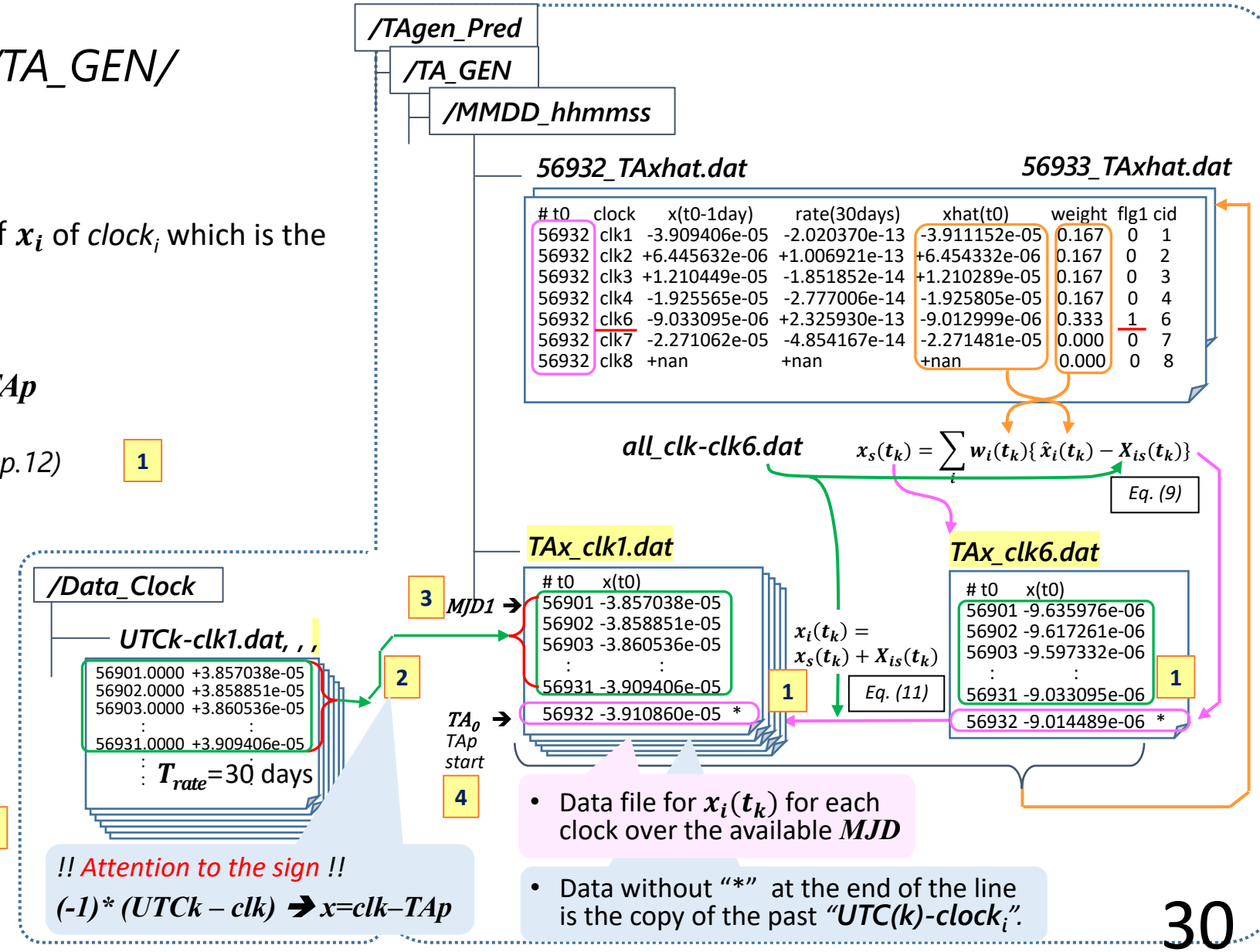
- 1st column : t_k: MJD to determine ***TAp***
- 2nd column : $x_i(t_k)$ of *clock$_i$*
  (derived from Eq.(9)(11) on p.12) 1

Note

※ Data without "*******" at the bottom of the line are the copies of the past "***UTC(k) – clock$_i$***". 2

※ The first date ***MJD1*** is the oldest date when the available clock data is provided, or is specified by 3 "*menu-1*".

※ The ***TAp*** start date is determined by "$TA_0 = MJD1 + T_{rate} + 1$". *(p.17)* 4



A-1. Input / Output files :

A-1.3. Output files of results

A-1.3.1 *"all_raw_clk_(time).dat"*

TAgen_pred.py

■ *"/Pytool_TAgen/TAgen_Pred/TA_RESULT/ (time)/**all_raw_clk_(time).dat**"*

Outline

- *"**all_raw_clk_(time).dat**"* is the combined data of '***UTC(k) – clock$_i$***', which is used for the left plot of "***fig_(time).pdf***" *(p.37)*
- This data file is generated at the end of *Initial processing* on demand.

Details / Rules of use

- 1st line : clock file name
- 2nd line : *weight* : copy of the 3rd column of "*clock_file_list.txt*"
- 3rd line : *flag* : copy of the 4th column of "*clock_file_list.txt*"
- 4th line : *cid* : copy of the 1st column of "*clock_file_list.txt*"
- 5th line ~ : copy of the "***UTC(k) – clock$_i$***" of "***UTCk_(clock$_i$).dat***" *(p.27)*
- *(time)* : ***MMDD_hhmmss*** : time stamp of data saving
  (***MMDD***: month & date, ***hhmmss*** : hour & minute & second)

Note

※ The clock with "**#**" in "***clock_file_list.txt***" *(p.25)* is excluded.

Pytool_TAgen/TAgen_Pred/TA_RESULT/0717_093343/

Clock_file_list.txt

```
# sum of weights is normalized
to 1 in the program.
# flg1=1 means the reference
clock of phase comparison.
# filename    : weight : flg1
1 UTCk-clk1.dat :  1   : 0
2 UTCk-clk2.dat :  1   : 0
3 UTCk-clk3.dat :  1   : 0
4 UTCk-clk4.dat :  1   : 0
#5 UTCk-clk5.dat :  2   : 0
6 UTCk-clk6.dat :  2   : 1
7 UTCk-clk7.dat :  0   : 0
8 UTCk-clk8.dat :  4   : 0
```

UTCk-clk1.dat

```
56901.0000  +3.857038e-05
56902.0000  +3.858851e-05
      :           :
57999.0000  +5.576701e-05
58000.0000  +5.578885e-05
```

all_raw_clk_0717_093343.dat

fname	UTCk-clk1.dat	UTCk-clk2.dat	UTCk-clk3.dat	UTCk-clk4.dat	UTCk-clk6.dat	UTCk-clk7.dat	UTCk-clk8.dat
Weight	1.0	1.0	1.0	1.0	2.0	0.0	4.0
flag	0	0	0	0	1	0	0
cid	1	2	3	4	6	7	8
56901	+3.857038e-05	-6.184638e-06	-1.215249e-05	+1.918367e-05	+9.635976e-06	+2.258480e-05	+nan
56902	+3.858851e-05	-6.197517e-06	-1.215115e-05	+1.919092e-05	+9.617261e-06	+2.258759e-05	+nan
:	:	:	:	:	:	:	:
58725	+nan	+6.693075e-06	-3.187783e-06	+2.707895e-05	-1.676407e-05	+4.440954e-05	+5.273111e-06
58726	+nan	+6.687379e-06	-3.180825e-06	+2.708426e-05	-1.677650e-05	+4.442301e-05	+5.270004e-06

A-1.3.2 *"all_raw_clk_TA_(time).dat"*

TAgen_pred.py

■ *"/Pytool_TAgen/TAgen_Pred/TA_RESULT/ (time)/**all_raw_clk_TA_(time).dat**"*

Outline

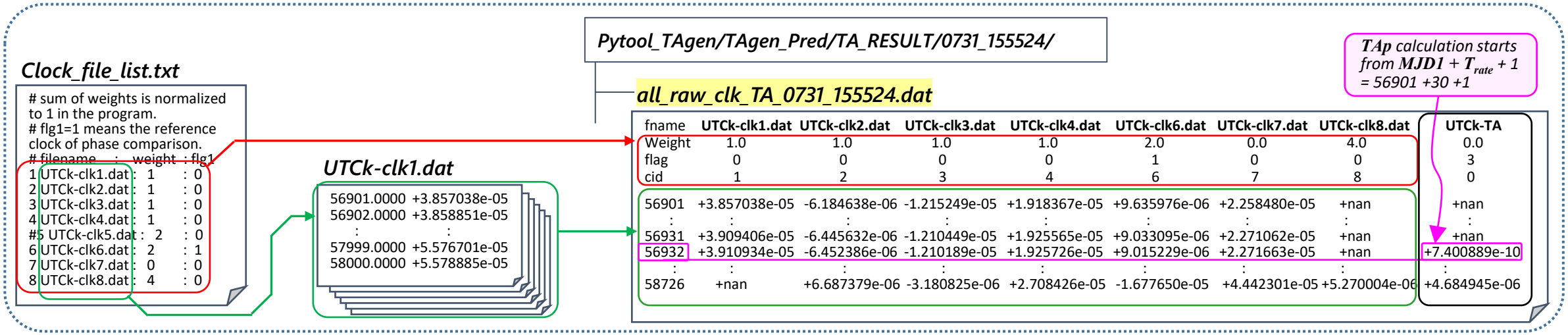
- *"**all_raw_clk_TA_(time).dat**"* is the combined data of *'**UTC(k) – clock$_i$**'* and *'**UTC(k) – TAp**'*.
- This data file is generated at the end of *"menu-2"* on demand.

Details / Rules of use

- The rules except for the last column data are the same as "***all_raw_clk_(time).dat***". *(p.32)*
- The last column:
  - The values of *weight, flag, cid* are not used in the program.
  - ***TAp*** calculation starts from $MJD1 + T_{rate}$ + *1day. (p.17)*

Note

※ The clock with "**#**" in "***clock_file_list.txt***" *(p.25)* is excluded.



A-1.3.3 *"all_adev_(time).dat"*

TAgen_pred.py

■ *"/Pytool_TAgen/TAgen_Pred/TA_RESULT/ (time)/**all_adev_(time).dat**"*

Outline

- *"**all_adev_(time).dat**" is the Allan deviation of the data of "**all_raw_clk_(time).dat**" or "**all_raw_clk_TA_(time).dat**".*
- This data file is generated at the end of *Initial processing* or *"menu-2"* on demand.

Details / Rules of use

- 1st line : clock file name
- 2nd line : ***MJDspan*** : the period used in the *ADEV* calculation.
- 3rd line ~ : Allan deviation calculated by by "***AllanTools***" *[Ref. 2]*.
- *(time)* : ***MMDD_hhmmss*** : time stamp of data saving
  (***MMDD*** : month & date, ***hhmmss*** : hour & minute & second)

1

Note

※ If there are not sufficient samples, *ADEV* cannot be calculated and is expressed as '***nan***'. 2

※ If the data is outlier (> ***x_limit, nan***), the data sequence is divided using the outlier as boundary. 3

※ If the data has discontinuous and divided into several blocks, the *ADEV* is plotted for each block and marked with ***"*1", "*2"***,,, . 4

*("UTCk_clk2.dat" shows the ADEV of [block-0], and "UTCk_clk2.dat*1" shows the ADEV of [block-1].)*

Pytool_TAgen/TAgen_Pred/TA_RESULT/0717_093410/

all_raw_clk_TA_0731_155524.dat

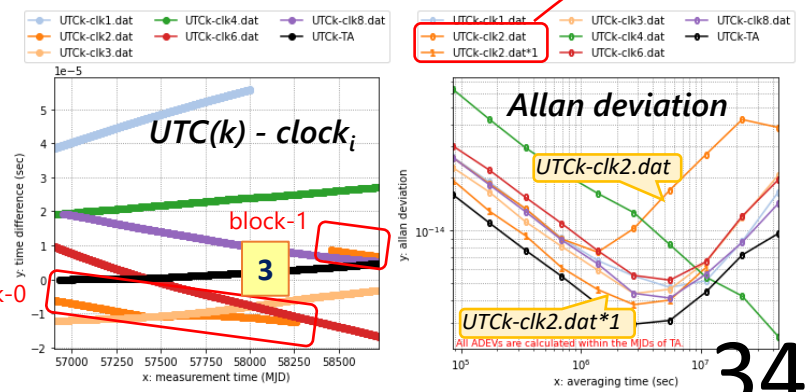
all_adev_0731_155524.dat

1

Tau(s)	UTCk-clk1.dat	UTCk-clk2.dat	UTCk-clk2.dat*1	UTCk-clk3.dat	UTCk-clk4.dat	UTCk-clk6.dat	UTCk-clk8.dat	UTCk-TA
MJDspan	56932-58000	56932-58260	58457-58726	56932-58726	56932-58726	56932-58726	56952-58726	56932-58726
86400	+2.593622e-14	+2.572997e-14	+1.914455e-14	+2.260179e-14	+6.282088e-14	+2.997311e-14	+2.576366e-14	+1.587481e-14
172800	+1.879802e-14	+1.838375e-14	+1.284166e-14	+1.647945e-14	+4.260514e-14	+2.195515e-14	+1.811728e-14	+1.101474e-14
:	:	:	:	:	:	:	:	:
11059200	+5.182775e-15	+2.695475e-14	+6.159347e-15	+6.611689e-15	+5.426419e-15	+6.643764e-15	+5.645967e-15	+4.474511e-15
22118400	+8.639638e-15	+4.250378e-14	+nan	+1.179217e-14	+4.242674e-15	+1.202004e-14	+8.546454e-15	+7.239207e-15
44236800	+1.646562e-14	+3.832687e-14	+nan	+2.051915e-14	+2.502899e-14	+1.933946e-14	+1.418509e-14	+9.593108e-15

4 2

fig_0717_093410.pdf 4



A-1.3.4 *"all_weight_(time).dat"*

TAgen_pred.py

■ *"/Pytool_TAgen/TAgen_Pred/TA_RESULT/ (time)/**all_weight_(time).dat**"*

Outline

- *"**all_weight_(time).dat**"* is the list of clock weights actually used in the ***TAp*** calculation.
- Each weight is normalized to be proportional to the initial value in the *"**clock_file_list.txt**". (p.25)*
- This data file is generated at the end of *"menu-2"* on demand.

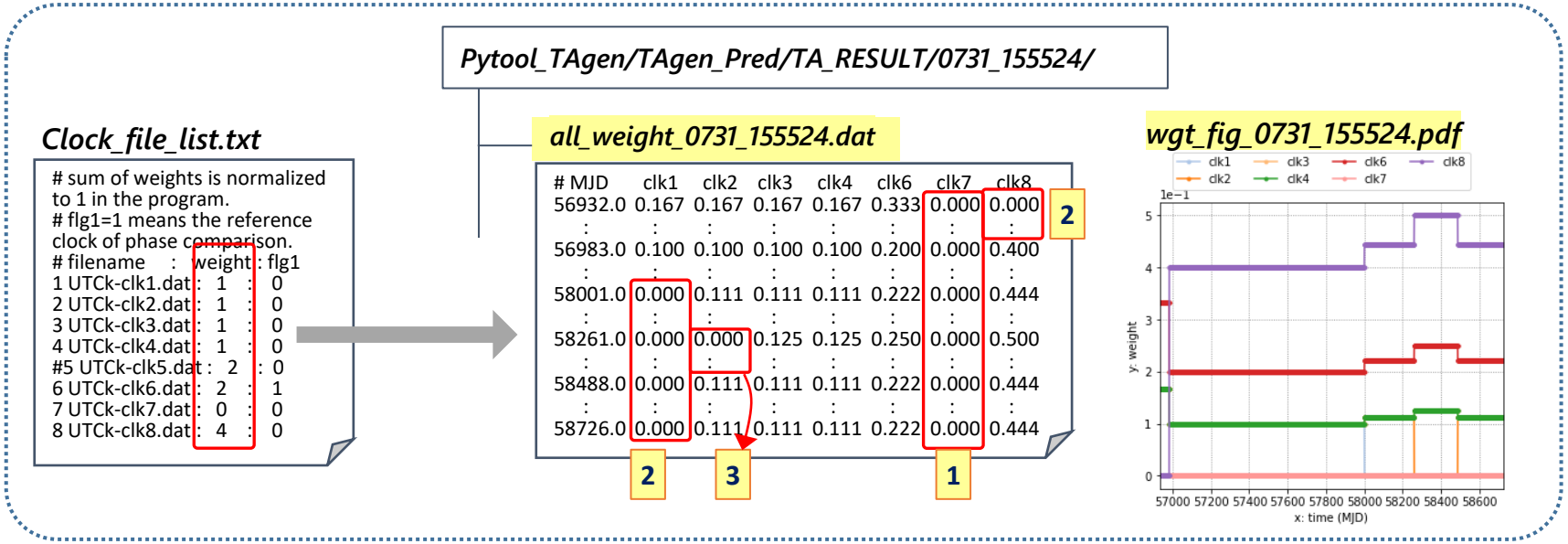
Details / Rules of use

- 1st line : clock name
- 2nd line ~ : clock weights actually used in the ***TAp*** calculation
- *(time)* : ***MMDD_hhmmss*** : time stamp of data saving
  (***MMDD*** : month & date ***hhmmss*** : hour & minute & second)

Note

※ The reason of zero weight:

1. Initial setting
2. Missing of clock data
3. Anomaly of clock data



A-1.3.5 *"log_(time).txt"*

■ *"/Pytool_TAgen/TAgen_Pred/TA_RESULT/ (time)/**log_(time).txt**"*

Outline

- *"**log_(time).dat**"* is the history of operation process.
- This file is generated at the end of *initial processing* or *"menu-2"* on demand.

Details / Rules of use

- Operated menu processes are serially added to this log file.
- The recorded parameters are actually used in the calculation.
- *(time)* : ***MMDD_hhmmss*** : time stamp of data saving
  (***MMDD*** : month & date ***hhmmss*** : hour & minute & second)

Note

※ The serially recording is reset when *"menu-0"* is selected.

Pytool_TAgen/TAgen_Pred/TA_RESULT/0731_155524/

log_0731_155524.txt

```
# Data log at 2025.07.31_15h55m_24s
#
**0** Read and plot initial clock data and Allan deviation*****
::::: Input clocklist   : clock_file_list.txt
::::: Input clock file  : ['UTCk-clk1.dat', 'UTCk-clk2.dat', 'UTCk-clk3.dat', 'UTCk-clk4.dat', 'UTCk-clk6.dat', 'UTCk-clk7.dat', 'UTCk-clk8.dat']
::::: data time interval (t_intval): 86400(sec)
::::: Outlier limit (x_limit))     : 1000.0

**2** make a timescale with predicton *****
::::: saved TAxhat data : ./TA_GEN/0731_155500/(MJD)_TAxhat.dat
::::: saved TAx data : ./TA_GEN/0731_155500/TAx_(clock).dat
::::: interval for rate estimation (TArate_span)      : 30(days)
```

A-1.3.6 *"fig_(time).pdf"*

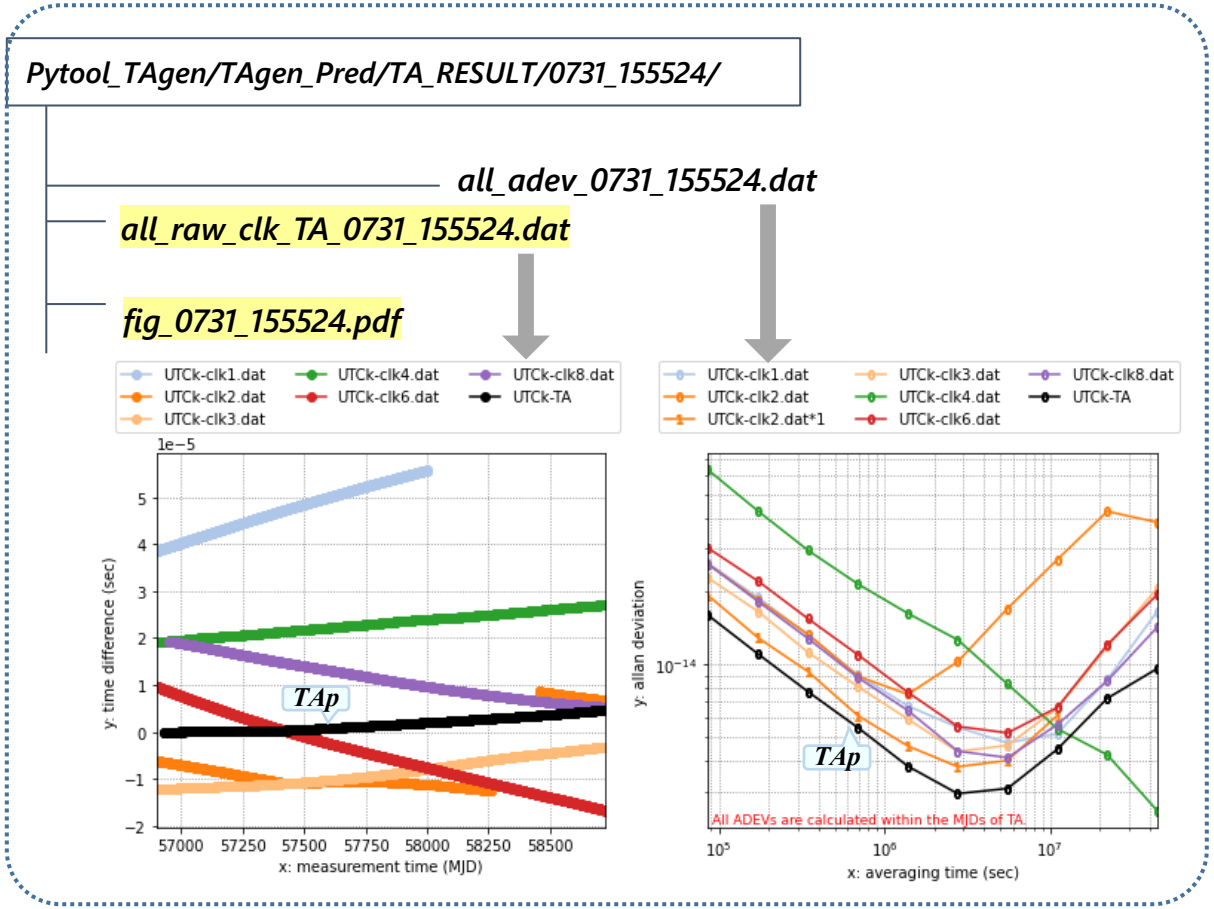
■ *"/Pytool_TAgen/TAgen_Pred/TA_RESULT/ (time)/**fig_(time).pdf**"*

Outline

- *"**fig_(time).pdf**" is the plots of time differences vs **UTC(k)** and their Allan deviations.*
- *This figure file is generated at the end of Initial processing or "menu-2".*

Details / Rules of use

- Left figure :
  - time differences of ***clock$_i$*** or ***TAp*** vs ***UTC(k)***
  - ***"all_raw clk_(time).dat"*** or ***"all_raw clk_TA_(time).dat"*** is used for this plot. *(p.32) or (p.33)*
- Right figure :
  - Allan deviations of the data for the left plot
  - ***"all_adev (time).dat"*** is used for this plot. *(p.34)*
- *(time)* : ***MMDD_hhmmss*** : time stamp of data saving
  (***MMDD*** : month & date ***hhmmss*** : hour & minute & second)



Note

- Only the clocks with non-zero weights are plotted.
- The black line shows the results of ***TAp***.

A-1.3.7 *"wgt_fig_(time).pdf"*

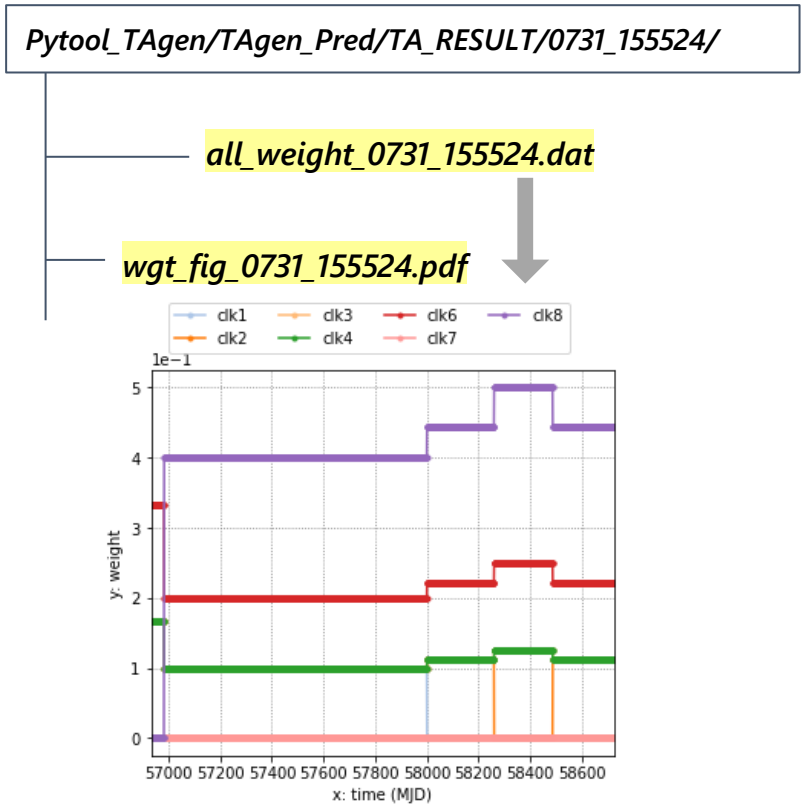
■ *"/Pytool_TAgen/TAgen_Pred/TA_RESULT/ (time)/**wgt_fig_(time).pdf**"*

Outline

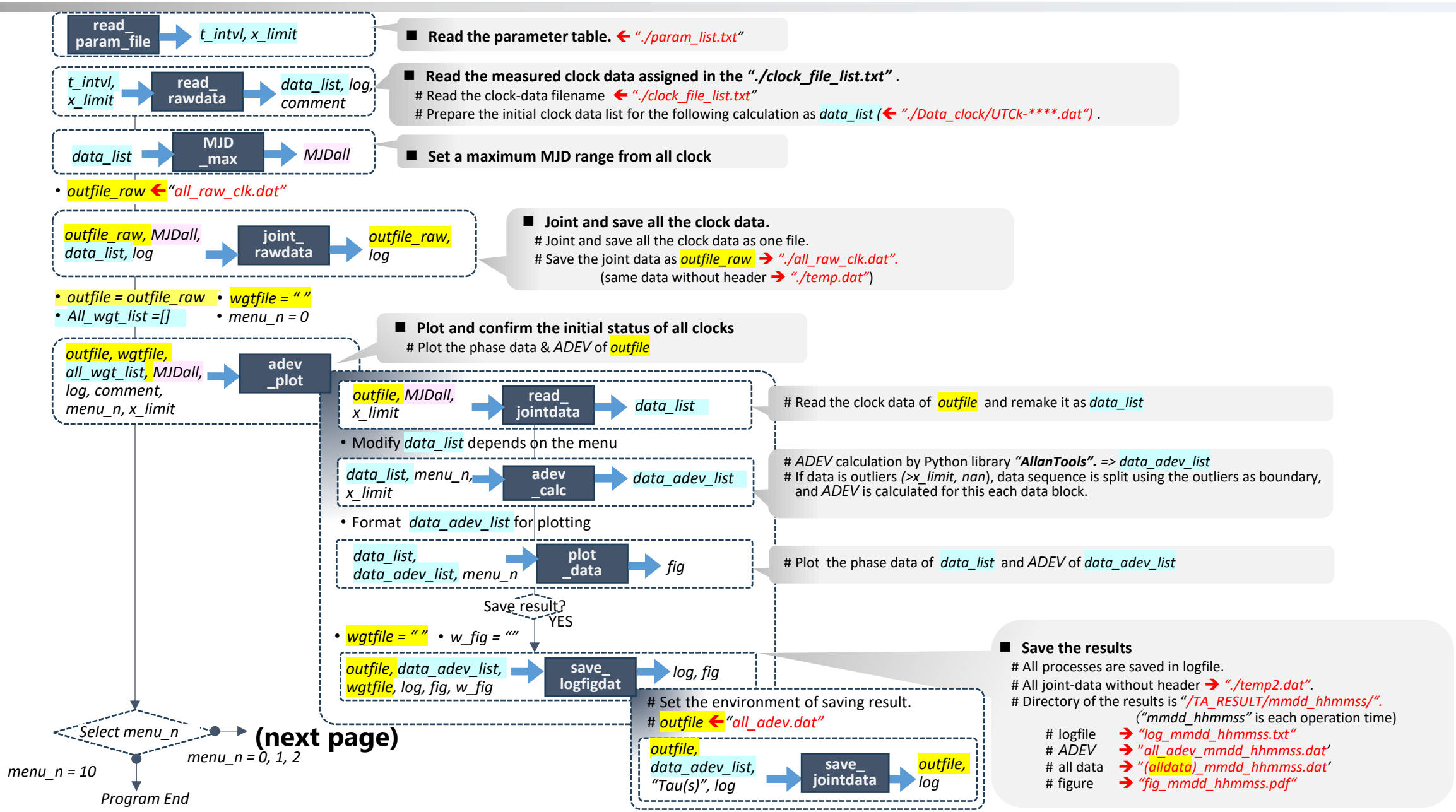
- *"**wgt_fig_(time).pdf**"* is the plots of actually used clock weights.
- This figure file is generated at the end of *"menu-2"*.

Details / Rules of use

- *"**all_weight_(time).dat**"* is used for this plot.
- *(time)* : ***MMDD_hhmmss*** : time stamp of data saving
  (***MMDD*** : month & date ***hhmmss*** : hour & minute & second)

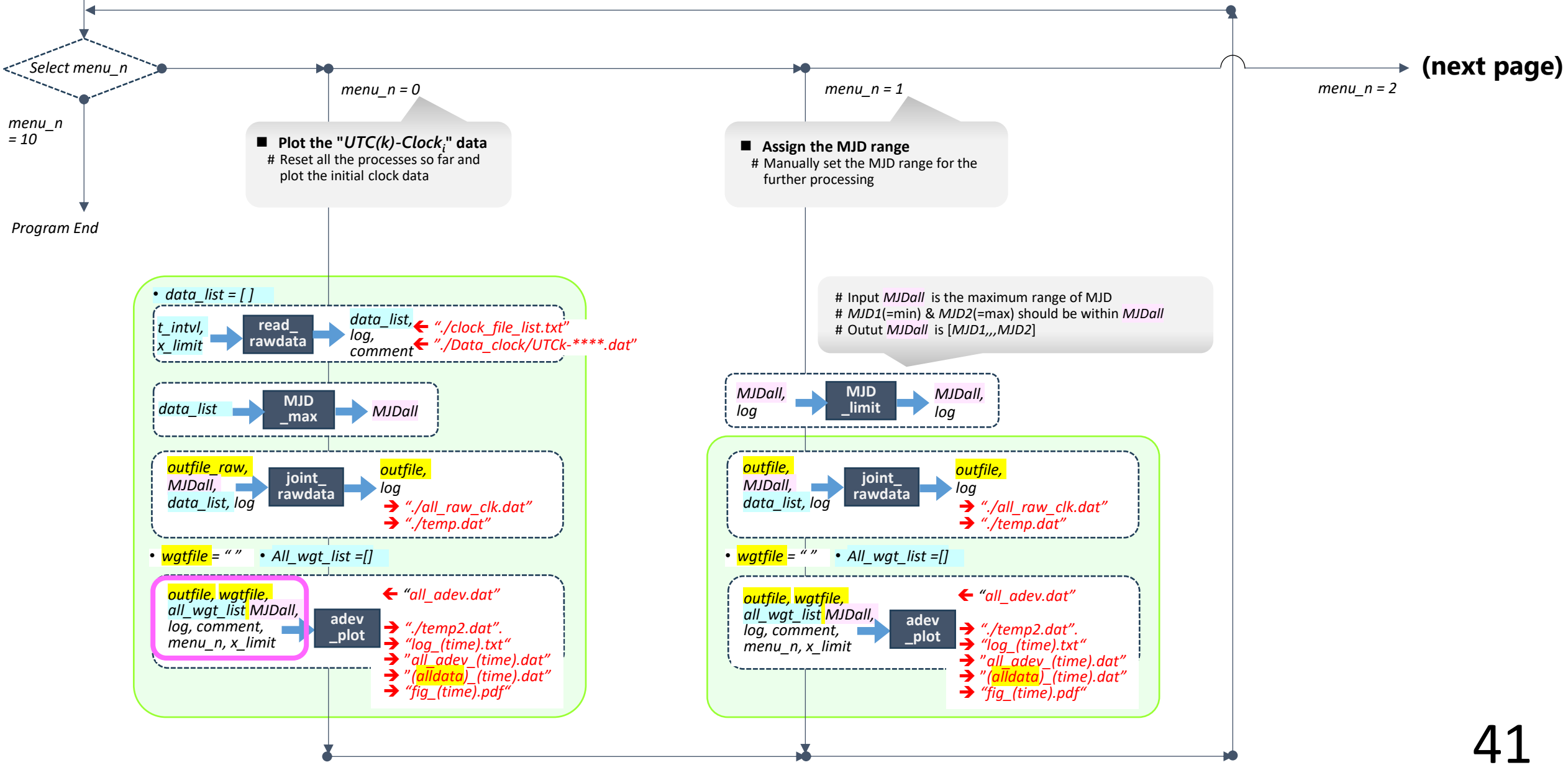


A-2. Construction and flow of the program


read_ param_file
t_intvl, x_limit
■ Read the parameter table. ← "./param_list.txt"
t_intvl, x_limit
read_ rawdata
data_list, log, comment
■ Read the measured clock data assigned in the "./clock_file_list.txt" .
Read the clock-data filename ← "./clock_file_list.txt"
Prepare the initial clock data list for the following calculation as data_list (← "./Data_clock/UTCk-****.dat") .
data_list
MJD _max
MJDall
■ Set a maximum MJD range from all clock
• outfile_raw ← "all_raw_clk.dat"
outfile_raw, MJDall, data_list, log
joint_ rawdata
outfile_raw, log
■ Joint and save all the clock data.
Joint and save all the clock data as one file.
Save the joint data as outfile_raw → "./all_raw_clk.dat".
(same data without header → "./temp.dat")
• outfile = outfile_raw
• wgtfile = " "
• All_wgt_list =[]
• menu_n = 0
■ Plot and confirm the initial status of all clocks
Plot the phase data & ADEV of outfile
outfile, wgtfile, all_wgt_list, MJDall, log, comment, menu_n, x_limit
adev _plot
outfile, MJDall, x_limit
read_ jointdata
data_list
Read the clock data of outfile and remake it as data_list
• Modify data_list depends on the menu
data_list, menu_n, x_limit
adev _calc
data_adev_list
ADEV calculation by Python library "AllanTools". => data_adev_list
If data is outliers (>x_limit, nan), data sequence is split using the outliers as boundary, and ADEV is calculated for this each data block.
• Format data_adev_list for plotting
data_list, data_adev_list, menu_n
plot _data
fig
Plot the phase data of data_list and ADEV of data_adev_list
Save result?
YES
• wgtfile = " "
• w_fig = ""
outfile, data_adev_list, wgtfile, log, fig, w_fig
save_ logfigdat
log, fig
■ Save the results
All processes are saved in logfile.
All joint-data without header → "./temp2.dat".
Directory of the results is "/TA_RESULT/mmdd_hhmmss/".
("mmdd_hhmmss" is each operation time)
logfile → "log_mmdd_hhmmss.txt"
ADEV → "all_adev_mmdd_hhmmss.dat"
all data → "(alldata)_mmdd_hhmmss.dat"
figure → "fig_mmdd_hhmmss.pdf"
Set the environment of saving result.
outfile ← "all_adev.dat"
outfile, data_adev_list, "Tau(s)", log
save_ jointdata
outfile, log
Select menu_n
menu_n = 0, 1, 2
(next page)
menu_n = 10
Program End

main program

: See the detail on *p.40*



main program

: See the detail on *p.40*

Select menu_n
- menu_n = 2
- menu_n = 10 → Program End

■ **Make TA with daily prediction and fixed clock weights**
Fixed weight is given by *"./clock_file_list.txt*

• *inflie_clklist* = *"./clock_file_list.txt"*

Inflie_clklist → clk_init_wgt → *clk_initparam*

■ **Get initial weight from** *"./clock_file_list.txt"*.
The weight of the reference clock (*flag1*=1) is set to be zero.

• *inflie_raw* ← *"./all_raw_clk.dat"*

infile_raw, MJDall, x_limit → TA_clk_clk → *diff_list*

■ **Prepare *the TAx$_{i0}$ (= clk_i – reference clock*) from the measurement raw data (** *"./all_raw_clk.dat"* **)**
The clock with *flag1*=1 is the reference clock ("*clk0*").
Save the result (*diffdata*) → *"./all_clk-(Refclk).dat"*

• *TAgen_dir* = *"./TA_GEN/"*

TAgen_dir → set_dirpath → *dt_str, dt_com, TAgen_path*

■ **Prepare the directory for data saving** (*"./TA_GEN/"*)

MJDall → TA_set ratespan → *TArate_span*

■ **Prepare the data span for rate prediction**
Any span is OK within *MJDall*.
Recommended values are *10 or 30 or 90.*

infile_raw, MJDall, TAgen_path, TArate_span, x_limit → TA_make_init_x → *TAx_list, TA_MJD0*

TAx_list → */ TAx_(clock$_i$).dat"*

■ **Prepare initial data for starting TA calculation**
TAx_list : initial data stock for starting TA calculation.
[[clkname, [[MJD],[clk-UTCk)]], wgt, flg, id],,,]
TA_MJD0 : the MJD of starting TA calculation

• ***for MJD in range(TA_MJD0, MJDall[-1]+1):***

TAx_list, MJD, clk_initparam → TA_wgt_reset → *TAx_list*

■ **Reset the clock weight to the initial given fixed value**
A clock with poor condition is temporarily assigned weight=0 and excluded from the calculation.
The purpose of this process is to reinstate the clock to the calculation when it recovers.

TAx_list, MJD, TAgen_path, TArate_span, fit_deg → TA_predict_x → *TAxhat_list*

■ **Calculate the *TAx* prediction (= *xhat*) for next day**
Slope is calculated in the latest span of TA*rate_span*
* *xhat = x[i] + slope * (t[i] - t[i-1])*
* *TAxhat_list : [[clkname, t1, x(t0), slope/86400, xhat(t1), wgt, flg, cid],,,]*
(t1 : assigned MJD, *t1 – t0* is 86400 sec)

• ***(cont. for loop:)***

TAx_list, TAxhat_list, diff_list, MJD, TAgen_path, TArate_span, x_limit → TA_calc_x → *TAx_list, , wgt_list, comment, log_TA*

■ **Calculate and save the *TAx***
Sum the available weights and do their normalization
TA_x0 = Sum of *{wgt_n * (TA_xhat - df_x)} for* each clock
* *TA_x0* : *TAx* of reference clock
* *TA_xhat* : predicted *TAx* of each clock
* *df_x* : measured time diff (each clock - reference clock)
* *wgt_n* : normalized weight of each clock
# *TA_x = df_x + TA_x0*
* *TA_x* : *TAx* of each clock
# *TAx_list_new : [[clkname, [[MJD], [TAx]], [wgt_n], flg, id],,,]*
→ rename as *TAx_list*
wgt_list : [[clkname, wgt_n, cid],,,]
Directory of the results is "*/TA_GEN/mmdd_hhmmss/".

TAx_list → */ TAx_(clock$_i$).dat"*
TAxhat_list → */ (MJD)_TAxhat.dat"*

• *all_wgt_list = [[MJD, wgt_list],,,]*

■ **Save weight**
wgtfile = "all_weight.dat"
all_wgt_list → save_weight → *wgtfile* → *"./all_weight.dat"*

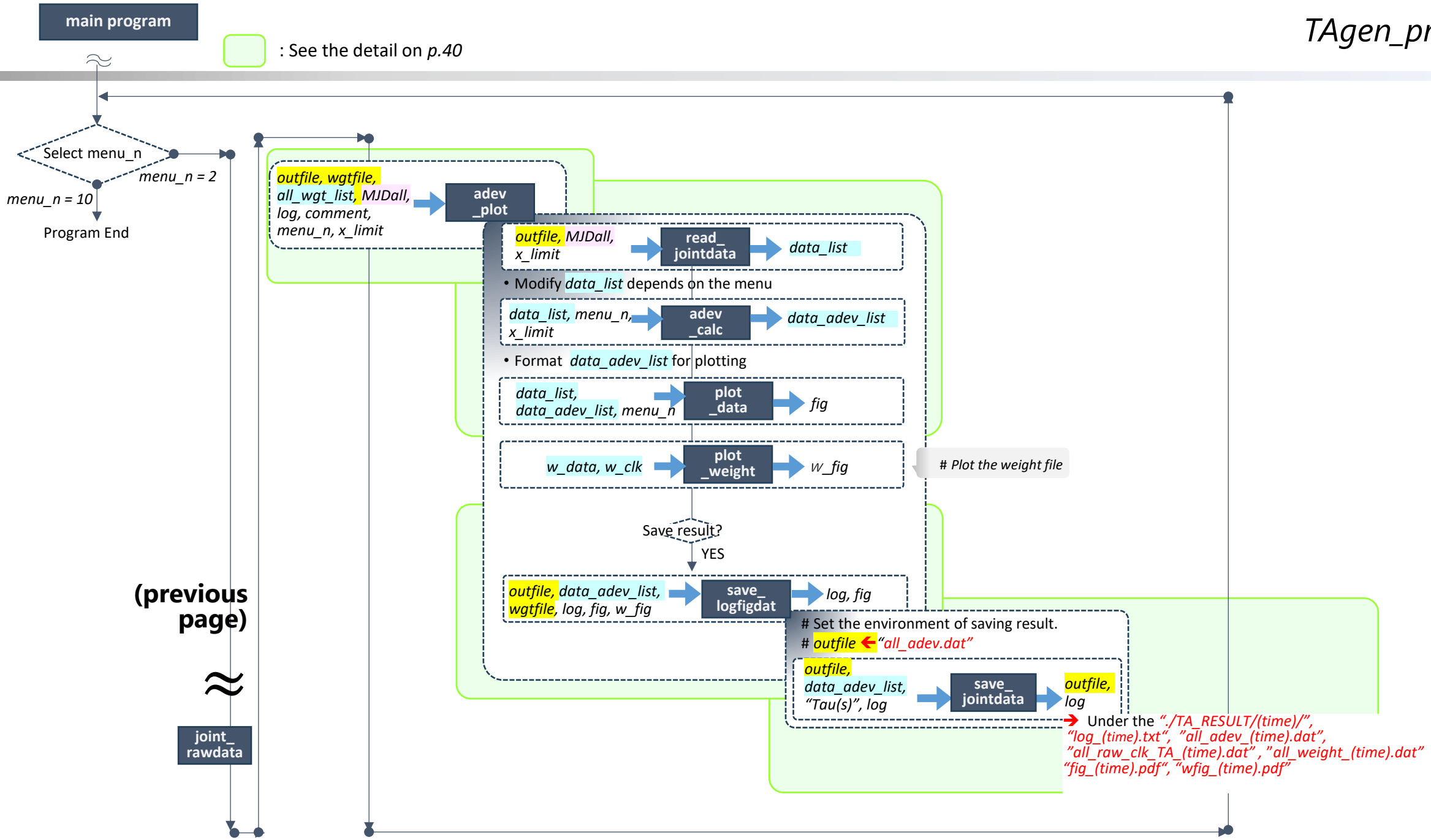
infile_raw, TAx_list, comment, TA_MJD0, x_limit → TA_ref_TA → *UTCk_TA_list, comment*

■ **Get the (UTCk -TA)**
"UTCk-TA" = "clk0-TA"(from *TAx_list*) +"*UTCk-clk0*"(from "*infile_raw*")
UTCk_TA_list : appended the *["UTCk-TA", data, "0.0", "3", "0"]*

• *outfile = "./all_raw_clk_TA.dat"*
• *log = log + log_TA*

outfile, MJDall, UTCk_TA_list, log → joint_rawdata → *outfile, log*
→ *"./all_raw_clk_TA.dat"*
→ *"./temp.dat"*

(next page)


main program
: See the detail on p.40
Select menu_n
menu_n = 2
menu_n = 10
Program End
outfile, wgtfile, all_wgt_list, MJDall, log, comment, menu_n, x_limit
adev _plot
outfile, MJDall, x_limit
read_ jointdata
data_list
• Modify data_list depends on the menu
data_list, menu_n, x_limit
adev _calc
data_adev_list
• Format data_adev_list for plotting
data_list, data_adev_list, menu_n
plot _data
fig
w_data, w_clk
plot _weight
w_fig
Plot the weight file
Save result?
YES
outfile, data_adev_list, wgtfile, log, fig, w_fig
save_ logfigdat
log, fig
Set the environment of saving result.
outfile ← "all_adev.dat"
outfile, data_adev_list, "Tau(s)", log
save_ jointdata
outfile, log
Under the "./TA_RESULT/(time)/", "log_(time).txt", "all_adev_(time).dat", "all_raw_clk_TA_(time).dat" , "all_weight_(time).dat" "fig_(time).pdf", "wfig_(time).pdf"
(previous page)
joint_ rawdata