



Clock Data Analysis and Visualization

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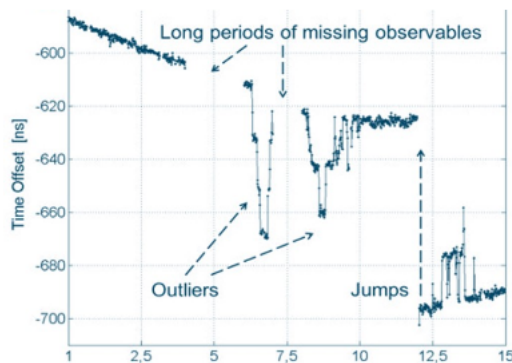


**Secondee at the BIPM
Time Department**

**Together with the BIPM Time
department
May 2025**

Clock Data Checking

Enrolment options



Clock Data Checking

This course aims at providing the knowledge of preliminary inspection of the Clocks Data which is the primary requirement in Time & Frequency Metrology. Inspecting the clock data, or any other measurement data, is important to check the quality of the data, identify possible issues, and correct outliers.

This course offers the following content to the user:

1. A domain expert presentation about basic techniques to check the measured clock data.
2. A browser-based software application "Clock Data Checking" .
3. The user manual and demonstrative video of the application.
4. The user manual and demonstrative video of the application.
5. Reference materials for the clock data processing and analysis.

The preparation of this course was co-sponsored by **IEEE-UFFC society**.

Course coordinator: BIPM Time department (tf.cbkt@bipm.org)

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Clock Data Checking

Input configuration

Upload Data Files  ▾

Input Data Settings  ▾

File Description  ▾

Data Format  ▾

Measurement Interval  ▾

Proceed to Analyse Data

Overview of the input settings

Files uploaded: NA

Data type: NA

Units data: NA

Signal frequency: NA

File combo: NA

Timestamp col: NA

Data col: NA

Tau0: NA

 **Raw Data**

 Data Range

 Detrend

 Offset

 Outlier

 Smoothing

 Stability

 Out come

Files Uploaded	Preview (Initial 1000 data points)	Select the Clocks	Clock Name
	empty		

Process Selected Clocks

Clock Data Checker

Input configuration

Upload Data Files  ▾

Input Data Settings  ▾

File Description  ▾

Data Format  ▾

Measurement Interval  ▾

Proceed to Data Checking

Upload the clock data files



Drag and drop files here

Limit 200MB per file

Browse files



UTck_Clk6.txt 48.1KB



UTck_Clk5.txt 48.1KB



UTck_Clk4.txt 48.1KB



Showing page 1 of 2



Submit

Select the type of Data you have:

☐ Phase/Time Data (s)

☒ Fractional Frequency

Select the frequency of the signal (MHz) 



Select the TIMESTAMP in column 1 

MJD ▾

Select the DATA column 

2 ▾

Select the file combination: 

☒ Each file is a different clock

☐ Multiple files of same clock

1

10

100

3600

86400

other

Raw Data

→←

Data Range

↗

Detrend

↗

Offset

⚡

Outlier

≡

Smoothing

📦

Stability

▶

Out come

Process Selected Clocks

✓ Confirms data has been uploaded and clock selection for data processing



Raw Data



**Data
Range**



Detrend



Offset



Outlier



Smoothing



Stability



Out come

Data Range: Allows the user to select the desired data range

How can it be used:

- ☐ To analyse only a specific portion of the data
- ☐ Discard the data recorded before and after the required time stamp/duration
- ☐ Provide visualization of the raw data set



Raw Data



Data Range



Detrend



Offset



Outlier



Smoothing



Stability

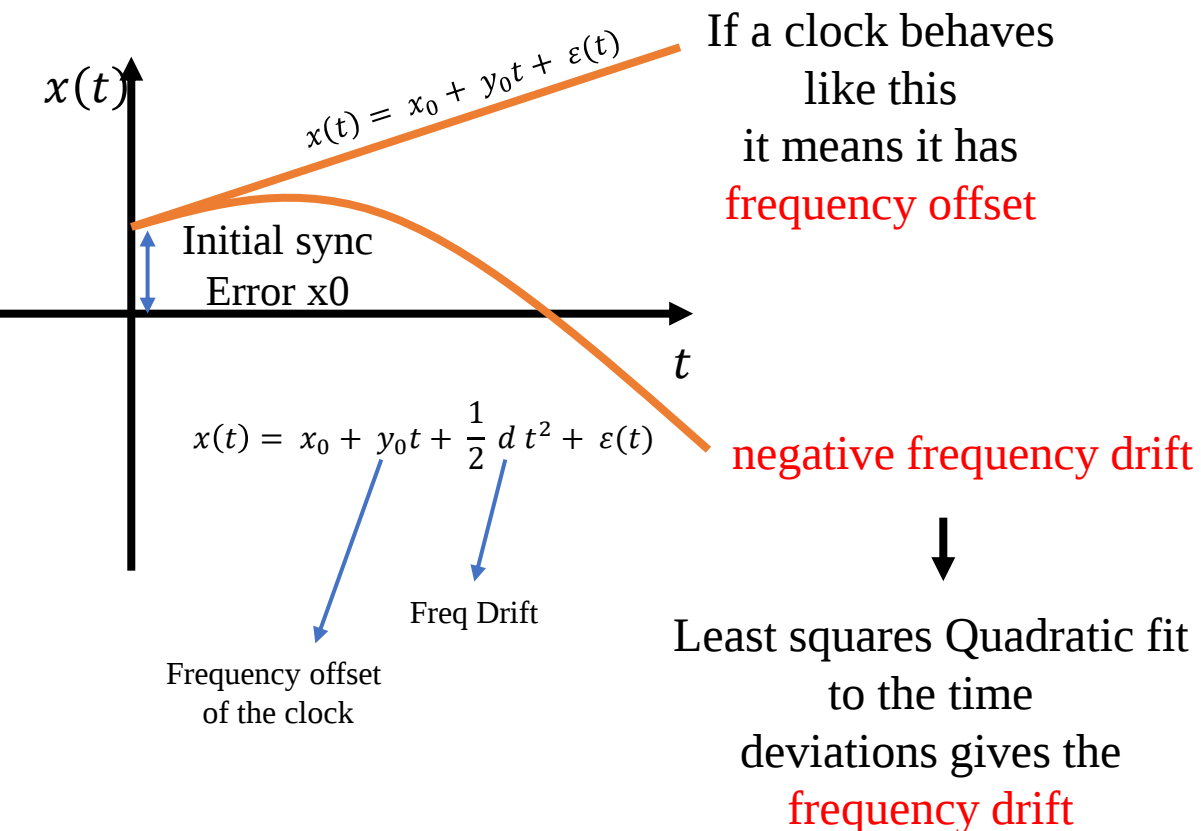


Out come

Requirement & Caution

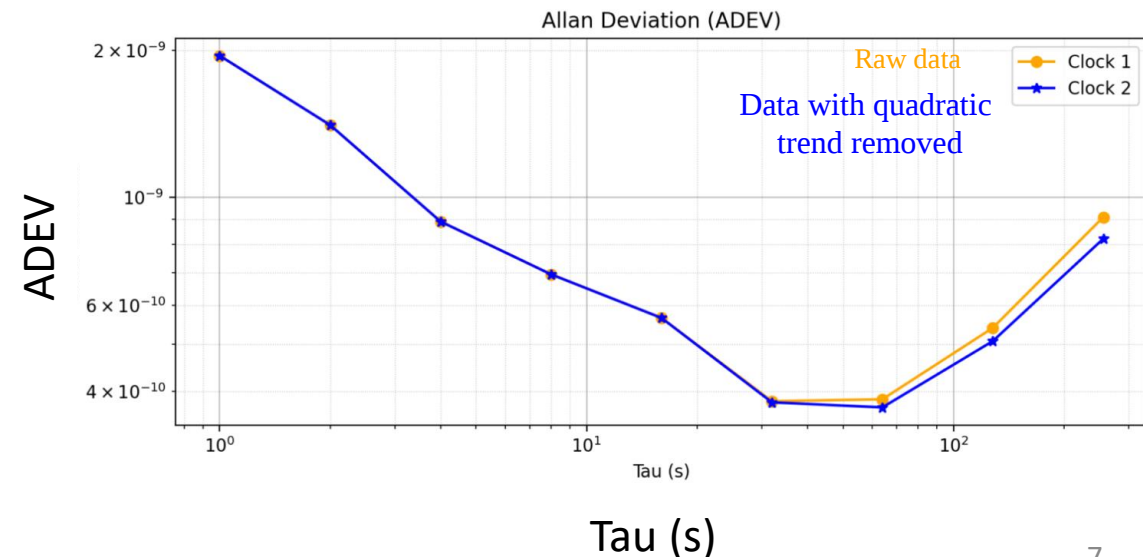
- To check for **frequency offsets** (Linear) and **frequency drifts** (quadratic) in the phase data

Time error Vs measurement time



Tip

- ❖ Removing the deterministic quadratic drift enables better visualization of other noise processes.

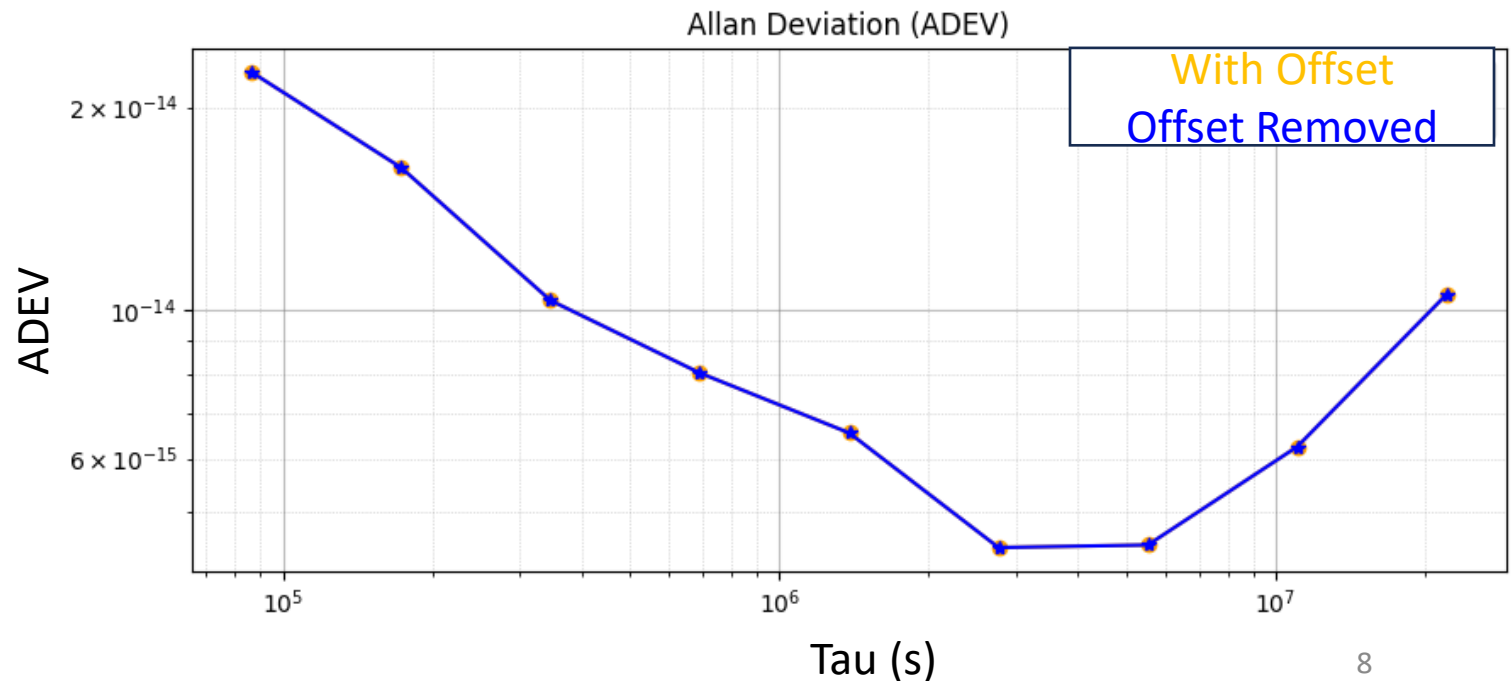
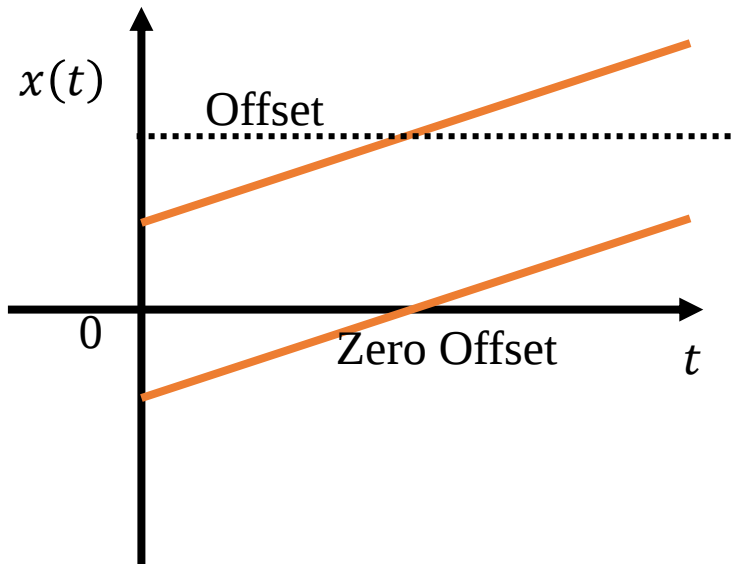




➤ **Offset:** To remove the offset in the data

Requirement & Caution

- ❑ Removing a constant frequency or phase offset **does not effect** the stability of the ADEV, MDEV etc.,



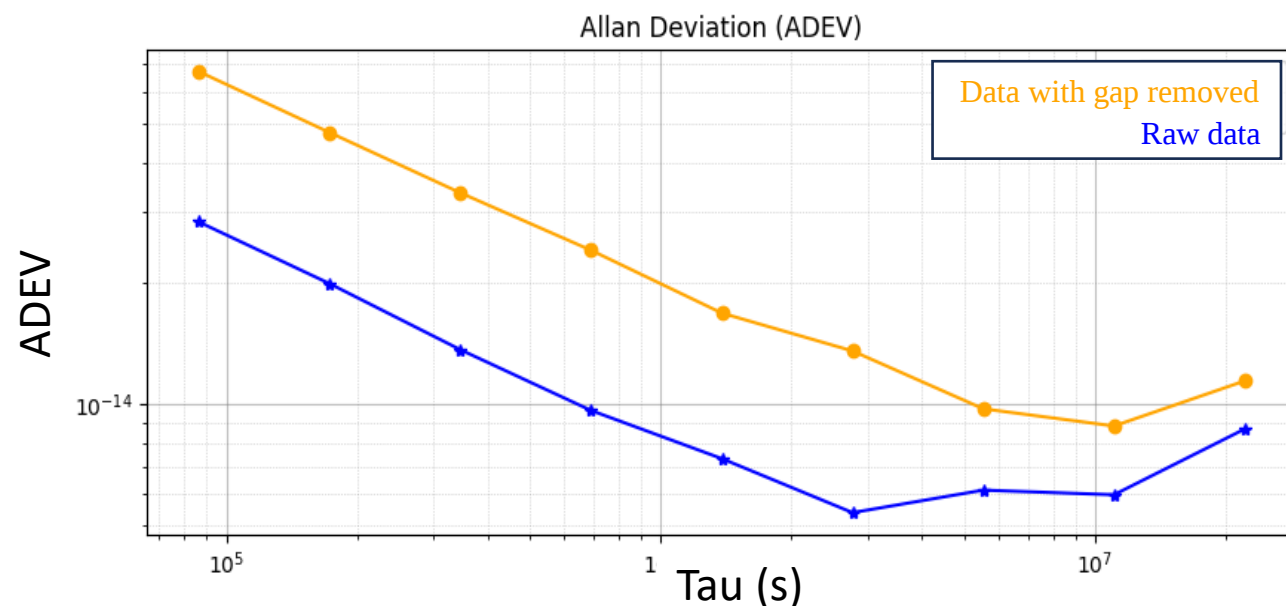
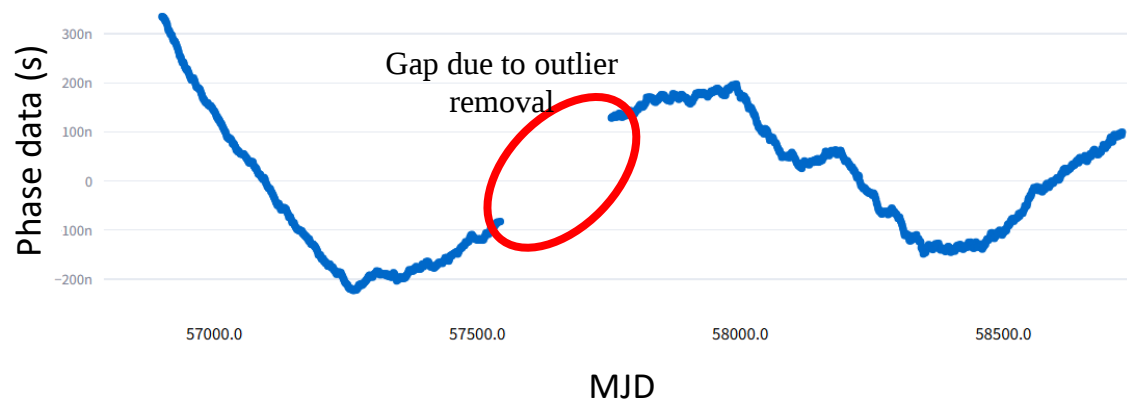
Overview of the functionalities in the application



➤ **Outlier:** Can remove the outlier manually or based on the std.dev of the data

Requirement & Caution

- ❑ Be careful to distinguish a true outlier from a data anomaly in the data.
- ❑ Removal of large sections of data can cause artificial steps in the data that can artificially increase the short-term instability of the calculated ADEV, MDEV etc. This is because the code automatically concatenates the data set.



Raw Data Data Range Detrend Offset Outlier

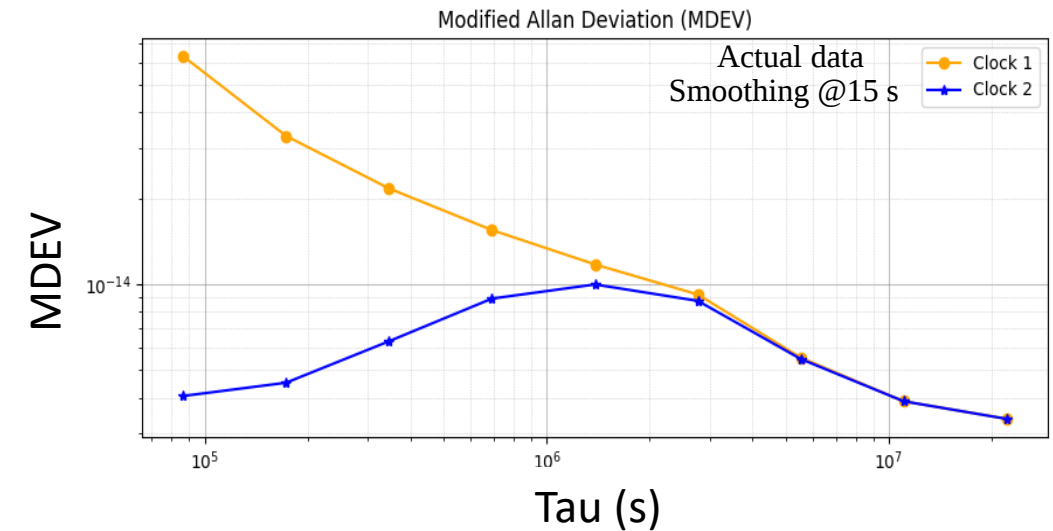
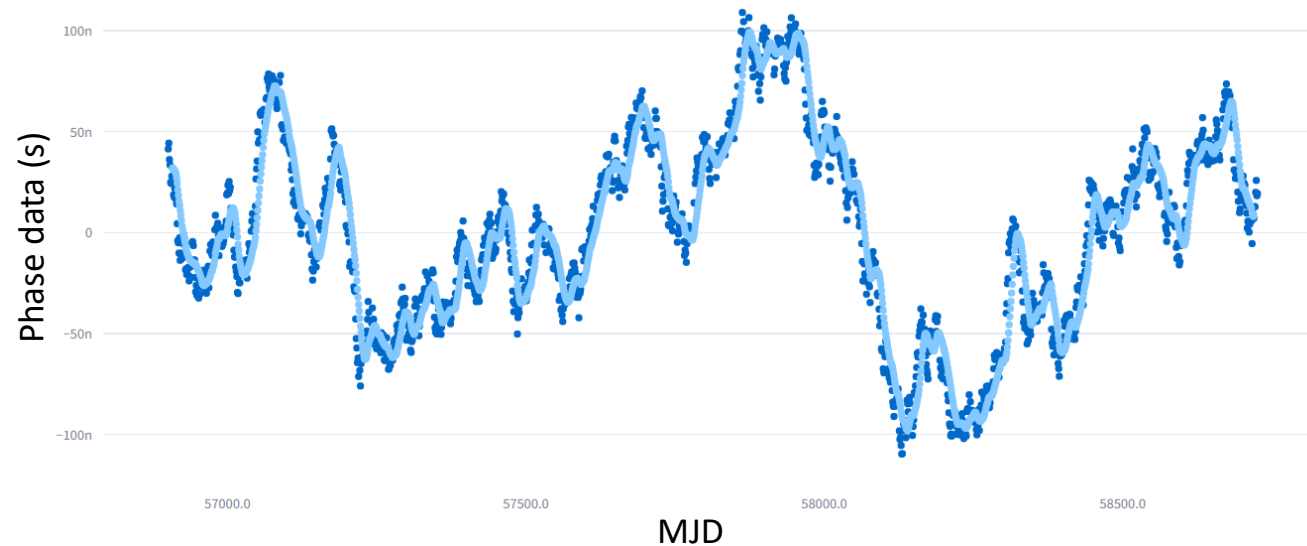
Smoothing

Stability Out come

➤ **Smoothing:** Apply a moving average by defining a window size

Uses & Caution

- ❑ To uncover underlying behavior after smoothing
- ❑ Removal of fast noise (this will remove short term data from the ADEV, MDEV, etc.)





- **Stability:** Can perform ADEV, MDEV, OADEV and TDEV (Courtesy: based on the open source ALLANSTOOL <https://pypi.org/project/AllanTools/>)
- ❖ **Allan Deviation (ADEV):** Square root of the two-sample variance
- ❖ **MDEV:** It is used to discriminate between white and flicker phase noise

	ADEV	MDEV	OADEV	TDEV
Overview	Computes first differences of fractional frequency over non-overlapping intervals.	Computes differences of time-averaged frequencies ; averaging filters high-frequency noise.	Same as ADEV but computed over overlapping intervals to increase the number of samples.	Derived from MDEV ; expressed in time units to represent time-domain instability.
Main usage	Standard tool for evaluating clock frequency stability over various averaging times.	Useful for distinguishing overlapping noise processes .	Improves confidence in ADEV estimates , especially at long averaging times with limited data.	Used in timekeeping to evaluate time jitter and synchronization stability.
Sensitivity to Noise	Slopes help identify dominant noise types , but white and flicker phase noise cannot be distinguished from each other using this method.	More sensitive to white ($\propto \tau^{-3/2}$) and flicker ($\propto \tau^{-1}$) phase noise than ADEV. The MDEV value depends on the averaging filter and the base sampling interval (τ_0).	Same noise sensitivity as ADEV, but with reduced statistical uncertainty due to more overlapping samples.	Same as MDEV, but expressed in time units instead of fractional frequency.

 Raw Data

 Data Range

 Detrend

 Offset

 Outlier

 Smoothing

 Stability

 Out come

➤ **Outcome:** Over-View of the actions you performed and their outcome

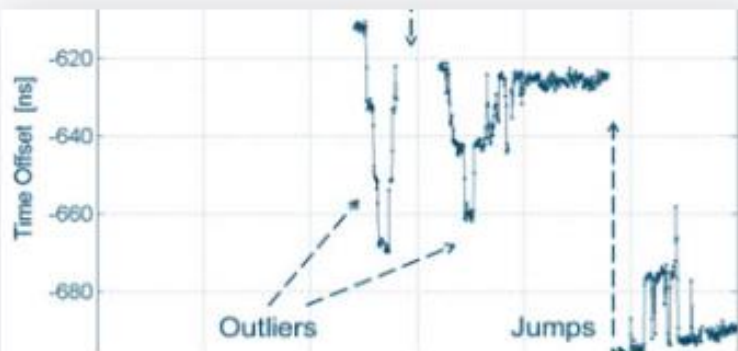
	Clock 1	Clock 2	Clock 3	Clock 4
Files uploaded	UTck_Clk5	UTck_Clk6	UTck_Clk7	UTck_Clk8
Data Type	Phase/Time Data (s)	Phase/Time Data (s)	Phase/Time Data (s)	Phase/Time Data (s)
Data Range	Start: 56901.0 End: 58726.0	Start: 56901.0 End: 58726.0	Start: 56901.0 End: 58726.0	Start: 56952.0 End: 58726.0
Measurement Interval [s]	86400	86400	86400	86400
Detrend	Method: Linear Equation: $x(t) = 9.76e-09t + 1.81e-05$	Method: Quadratic Equation: $x(t) = 2.05e-12t^2 + -1.77e-08t + 9.18e-06$	Method: Linear Equation: $x(t) = 1.27e-08t + 2.09e-05$	Method: Quadratic Equation: $x(t) = 1.65e-12t^2 + -1.11e-08t + 1.95e-05$
Offset Removed	Method: None Mean Before [s]: -1.60e-21	Method: None Mean Before [s]: N/A	Method: None Mean Before [s]: N/A	Method: None Mean Before [s]: N/A
Outlier Filtered	Method: None	Method: None	Method: None	Method: Std_Dev Based Multiplier: 1.50e+00

Let's work on the actual application

<https://cbkt-time.bipm.org/clock-data-checking/>

Test cases

1. Effect of **detrend** on the data (Ex: **UTCk_Clk1.txt**, **UTCk_Clk3.txt**)
2. Effect of **Gaps/dead time** in the data on the stability of the clock (Ex: **UTCk_Clk2.txt**)
3. Effect of **outlier** removal on the stability (Ex: **UTCk_Clk5.txt**)
4. Effect of the **offset** removal in the data (Ex: **UTCk_Clk4.txt**)
5. Effect of **Phase jumps** in the data (single jump or Uniformly distributed jumps) (Ex: **UTCk_Clk2.txt**)
6. Effect of **Periodic Phase Correction** (Sawtooth behaviour) on the stability of the clock (Ex: **Phase_steered.txt**)
7. Effect of **Frequency Steered** clock data (Ex: **Steered_Periodical.txt**)
8. Analyse **different portions** of the data at a time
(upload same file with different names, select each portion as a clock)
9. **Backward tasks**: If we want to remove the outliers first and then detrend
(download the file after outlier removal and upload it)



CLOCK DATA CHECKING

This course aims at providing the knowledge of preliminary inspection of the Clocks Data which is the primary..

VIEW

Thanks for your participation

<https://e-learning.bipm.org/>