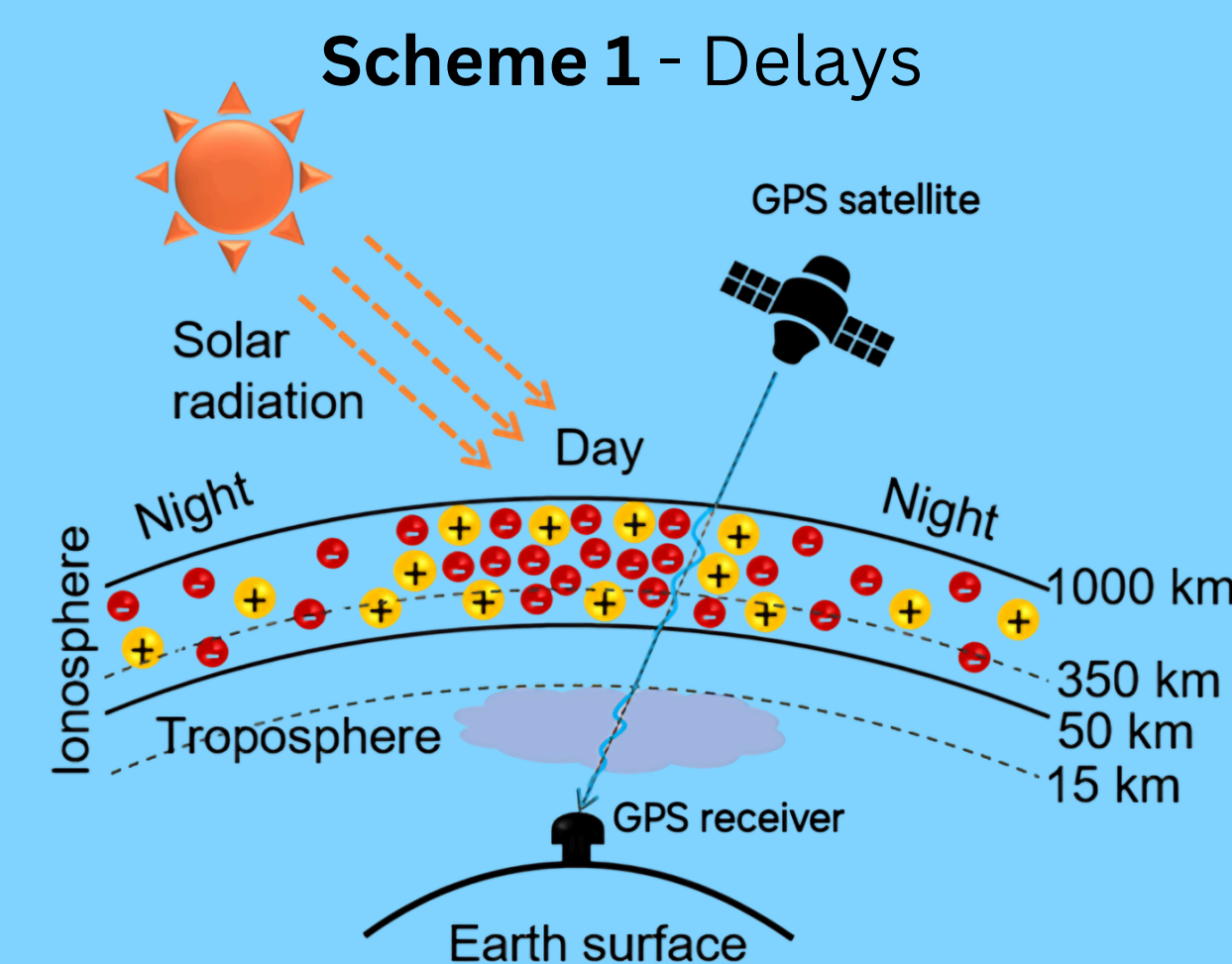


TROPOSPHERIC DELAY - IONOSPHERIC MONITORING

The rubidium atomic clock continuously receives GPS satellite's signals for self-calibration and it determines time difference:

THE CLOCK SCANS THE ATMOSPHERE!



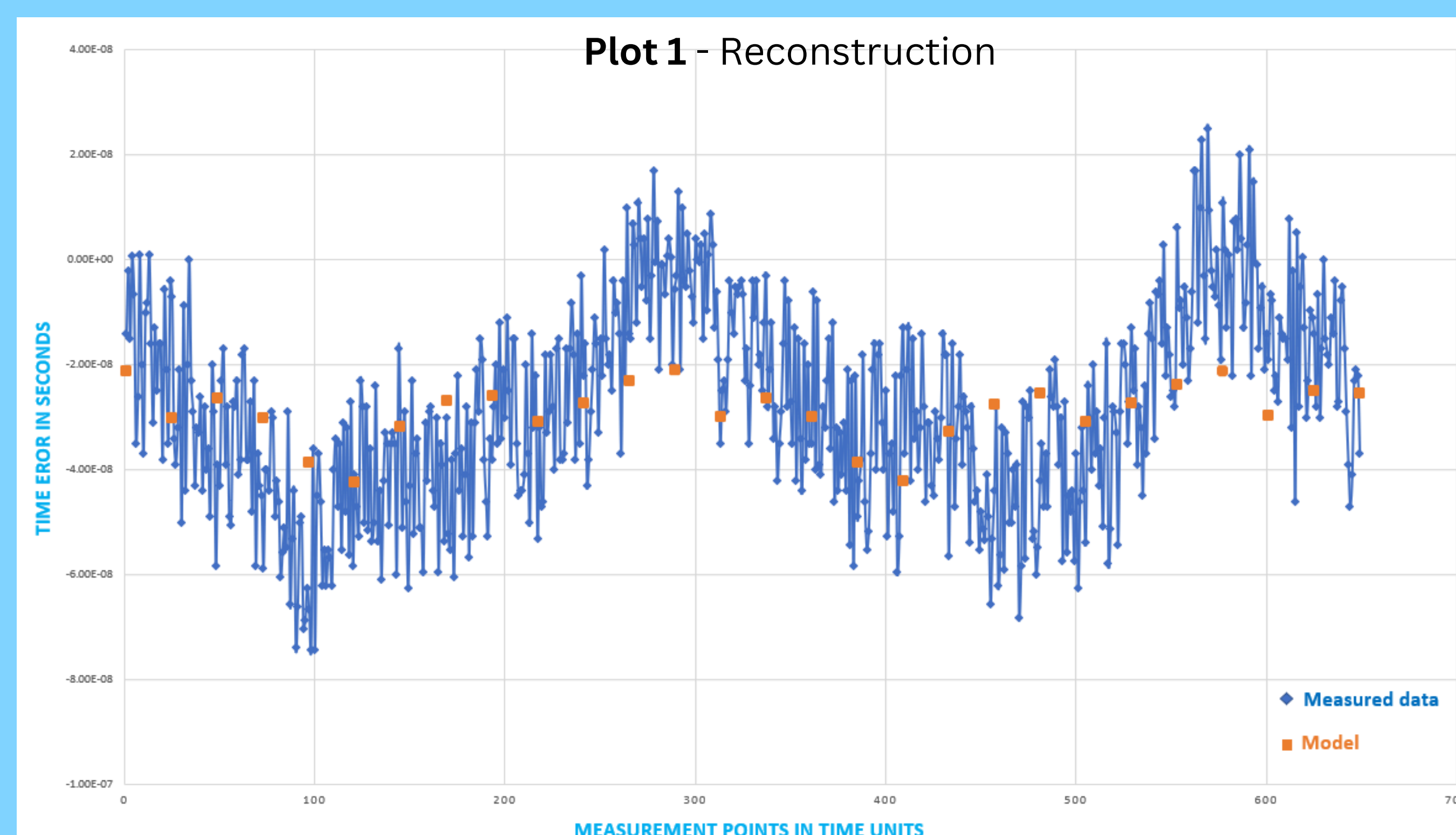
Our approximation (model) for tropospheric delay:

$$t_{trop_del} = \frac{h}{c * \sin \alpha} (n - 1) \quad 1)$$

h - average height of troposphere
 c - speed of light in vacuum
 α - elevation angle
 n - average refractive index

Ionospheric delay is calculated by using delay formula [1][2] and IGS data (TEC values) [3]

RESULT: Model matches the clock's data



CONCLUSION:

- Our model can describe the tropospheric delay
- Our model can be used for real-time partial removal of tropospheric delay, helping to reduce positioning uncertainty
- The ionospheric delay can be estimated by using the model and atomic clock
- Indirectly, monitoring of solar activity can be possible

☑ **+YES. IT IS ALSO A TOOL FOR IONOSPHERIC MONITORING WITHOUT USING THE SATELLITE DATA**

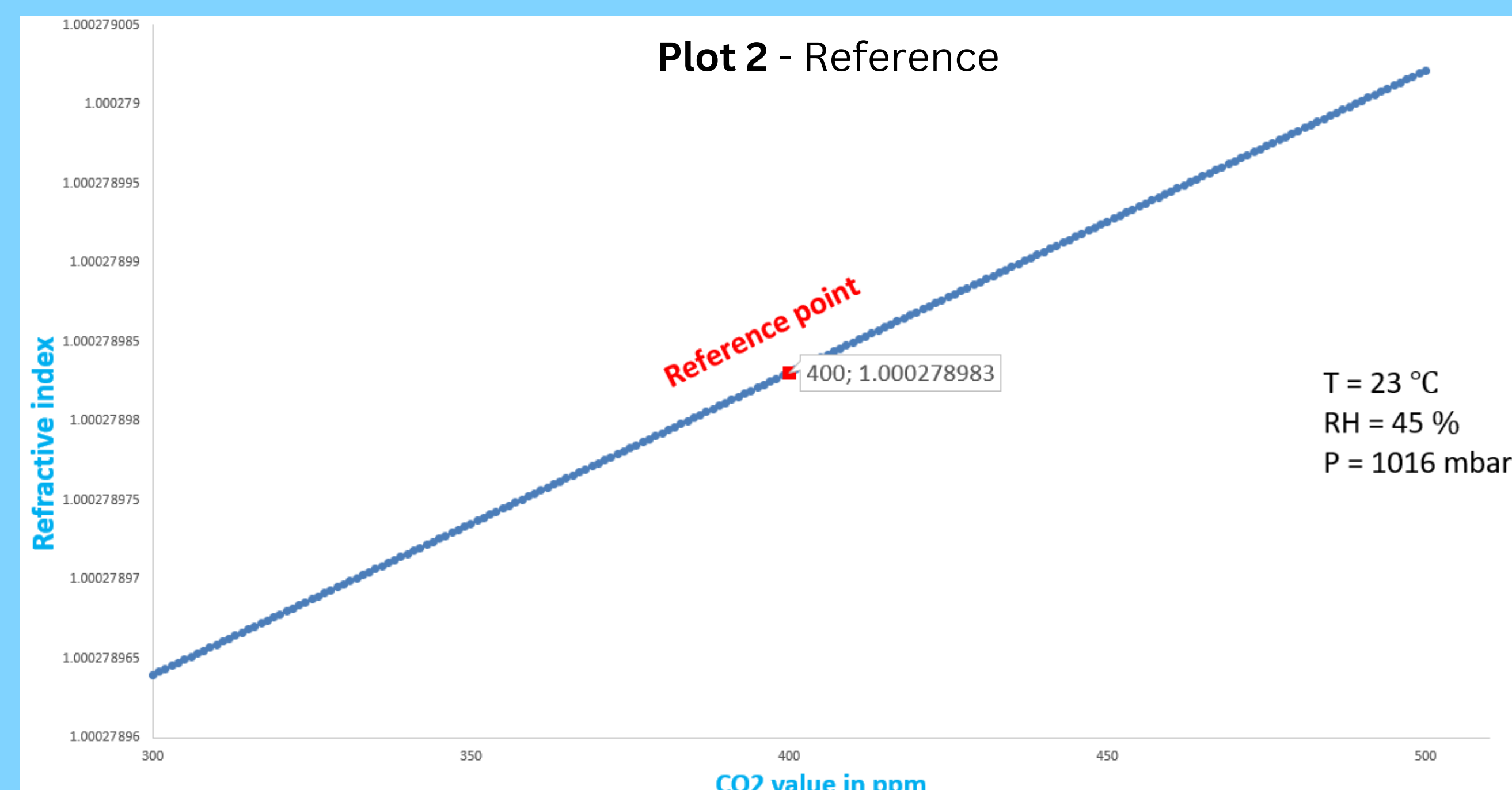
CO2 MONITORING - ALTERNATIVE METHOD

n - Refractive index of the medium (here, air) depends on:

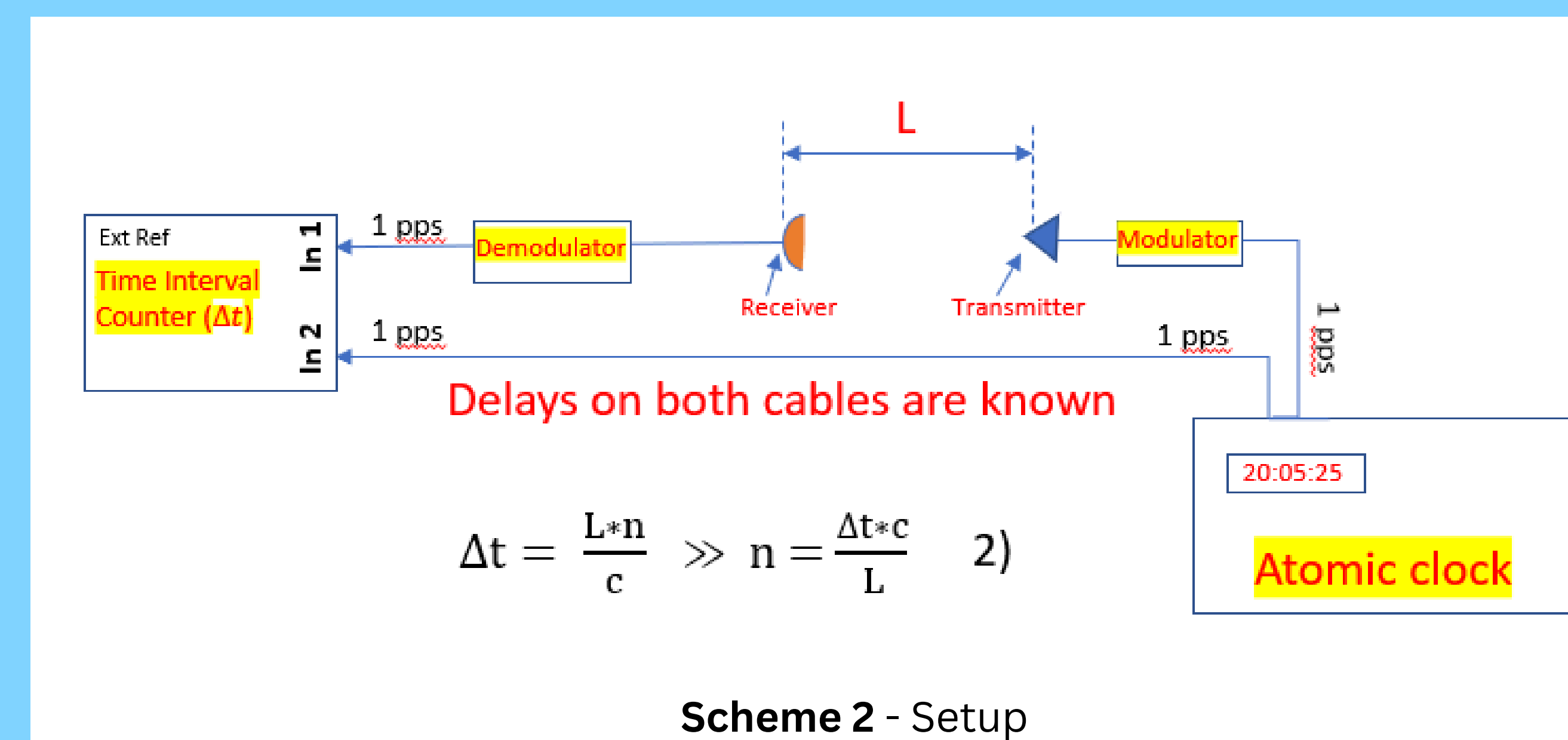
- Air Temperature (T), Relative Humidity (RH), Pressure (P)
- Signal frequency (f) - Predefined
- CO2 - carbon-dioxide value

The refractive index can be calculated by the Ciddor [4] or Radio refractive index [5][6] due to signal frequency

RESULT: The linear relation exists between CO2 value and n



CONCLUSION: Setup for monitoring



$$\Delta t = \frac{L * n}{c} \gg n = \frac{\Delta t * c}{L} \quad 2)$$

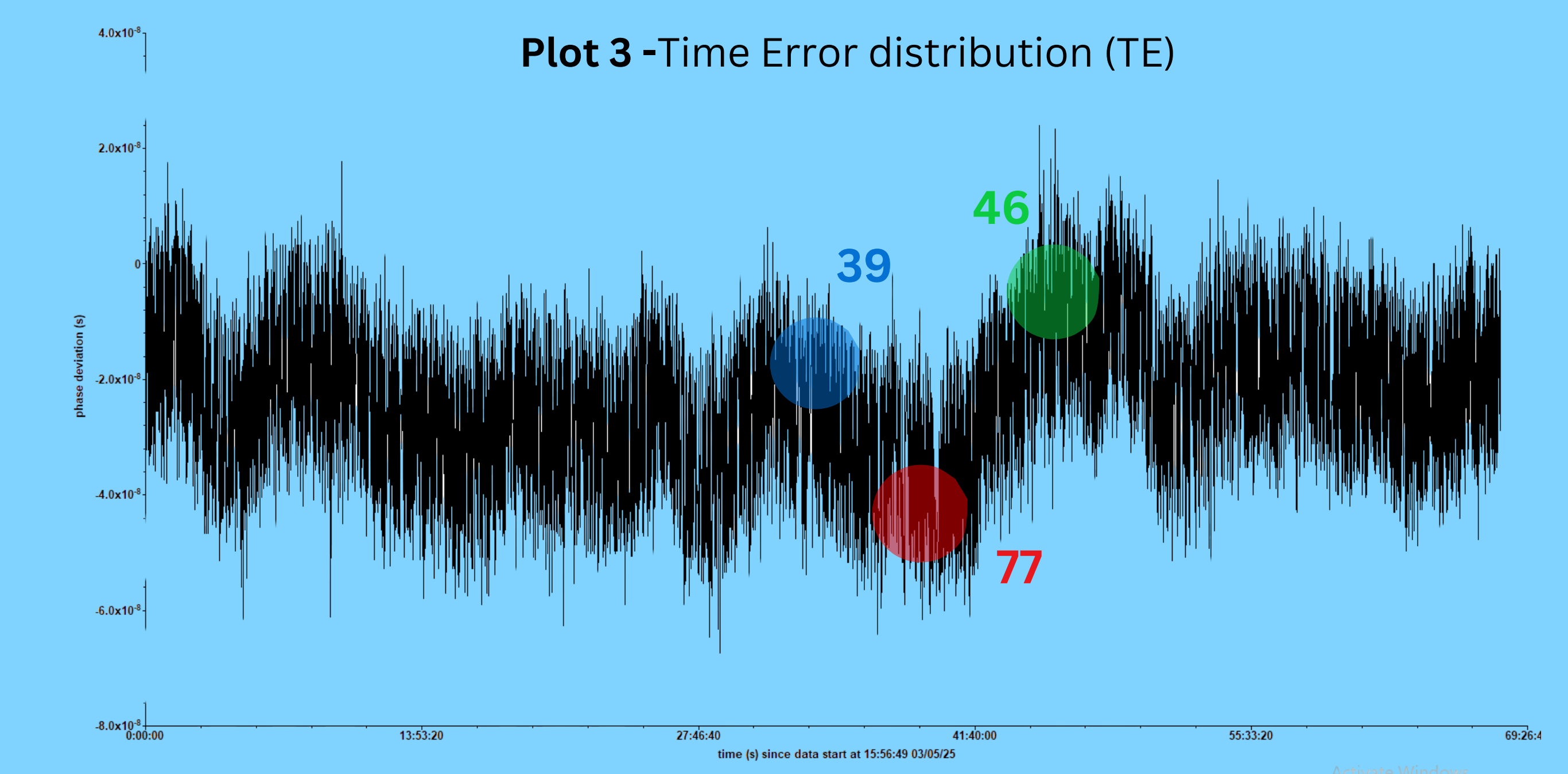
Scheme 2 - Setup

- Under reference environmental conditions, changes in CO2 levels relative to the reference point can be determined using the experimental setup described in Scheme 2

☑ **+ YES. IT IS ALSO TOOL FOR THE CO2 MONITORING**

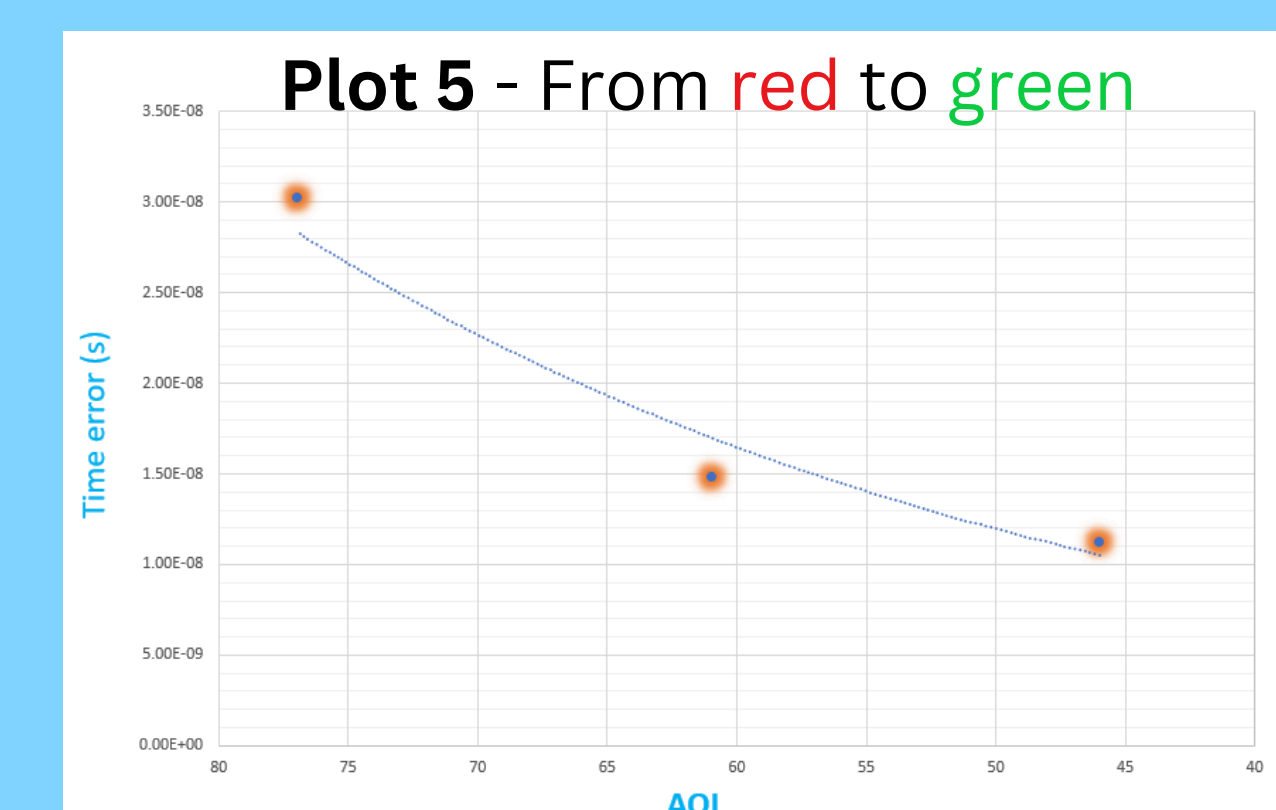
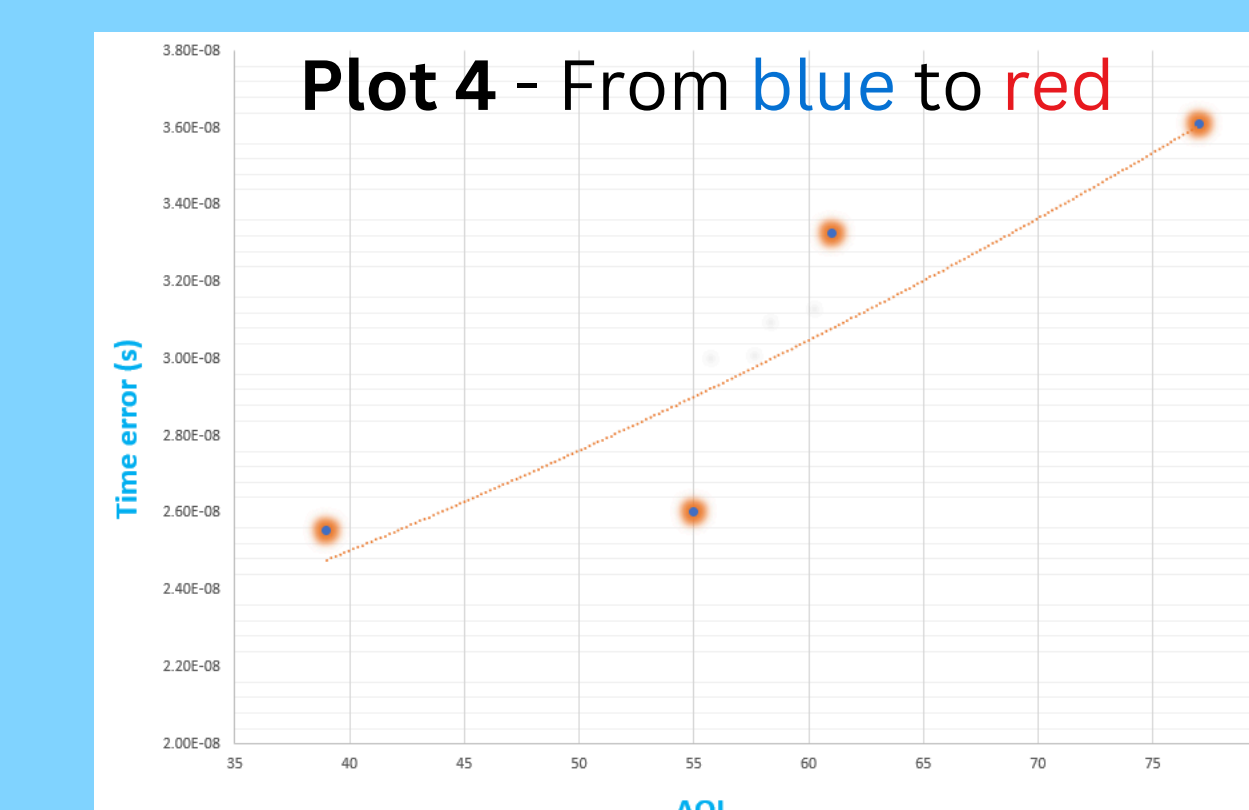
AIR POLLUTION MONITORING

There is currently no comprehensive mathematical formula that directly describes the relationship between air pollution levels and atmospheric delay, although various environmental factors affected by pollution can influence delay



AQI (Air Quality Index) data was obtained from online resource [7]. Time error values were obtained from Rb atomic clock

RESULT: Linear (or exp.) relation exists between AQI and TE



An increase in AQI (which describes particles with a diameter of 2.5 micrometers or smaller, among others) slows down the signal's velocity, causing more time delay in the troposphere (Plot 4). Conversely, a decrease in AQI leads to a faster signal velocity and less delay (Plot 5)

CONCLUSION:

- Time error (TE) quantity holds information about air pollutant such as various sized dust particles. The relation may be used as indicator for air pollution level

☑ **+ YES. IT IS ALSO TOOL FOR THE AIR POLLUTION MONITORING**

REFERENCES:

- 1) Estimation and Compensation of Ionospheric Propagation Delay in Synthetic Aperture Radar (SAR) Signals, Giorgio Gomba
- 2) Ionospheric Time-Delay Algorithm for Single-Frequency GPS Users , John A. Klobuchar
- 3) <https://igs.org/products/#ionosphere>
- 4) Automatic unit for measuring refractive index of air based on Ciddor eq. and its verification using direct interferometric meas. meth. DOI:10.1117/12.2020756
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- 6) Refractive Index Formulae for Radio Waves, Jean M. RÜEGER, Australia
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