

The background of the slide features a large, faint, semi-circular radar grid. The grid consists of concentric circles and radial lines, creating a grid pattern that is centered on the left side of the slide and extends towards the right. The grid lines are thin and light gray, blending into the dark gray background.

# APL Time and Frequency Lab Report

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56<sup>th</sup> CGSIC Meeting – Timing Subcommittee

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# The Johns Hopkins University Applied Physics Laboratory



The largest University Affiliated Research Center in the United States

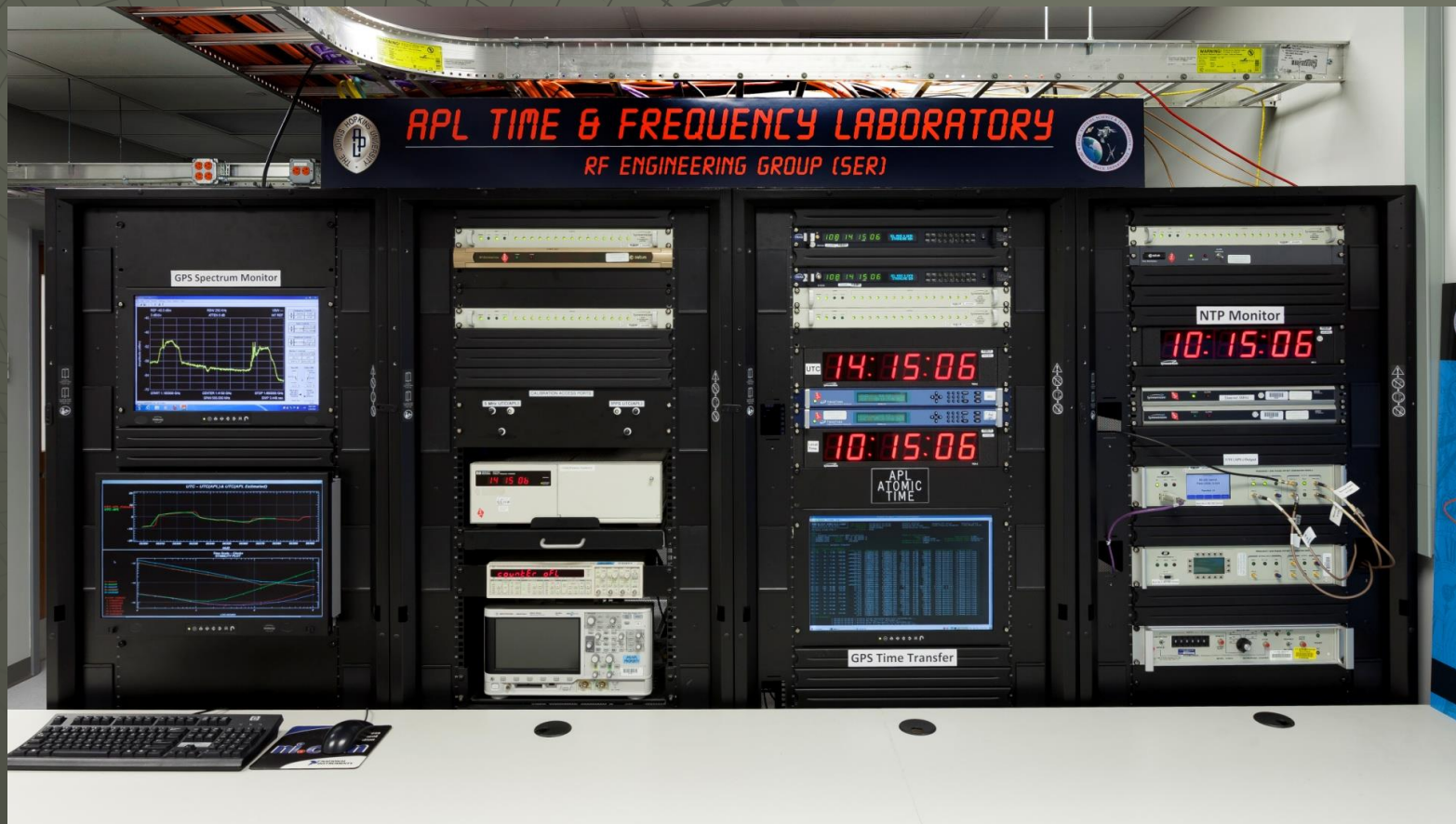
Located between Baltimore, MD and Washington, DC in Laurel MD on 450 acres with 20 major buildings + satellite campuses

Staff of about 5800 employees (77% are engineers & scientists)

Major sponsors are the DoD, NASA, DHS, and IC

# Time and Frequency Lab (TFL) Mission

Provide precise time and frequency in support of critical APL projects and maintain traceability to U.S. and international timing laboratories.





# APL TFL Hardware

- ◆ 3 High Performance Cesium Clocks
- ◆ 1 Standard Performance Cesium Clocks
- ◆ 3 Hydrogen Maser Clocks
- ◆ 2 5MHz clock measurement systems
- ◆ 1 1pps clock monitor system
- ◆ 2 High Resolution Offset Generators
- ◆ 3 GPS Time Transfer Receivers
- ◆ 1 Precision Distribution System (1PPS, 5Mhz, 10Mhz)

# APL TFL Clock Vault



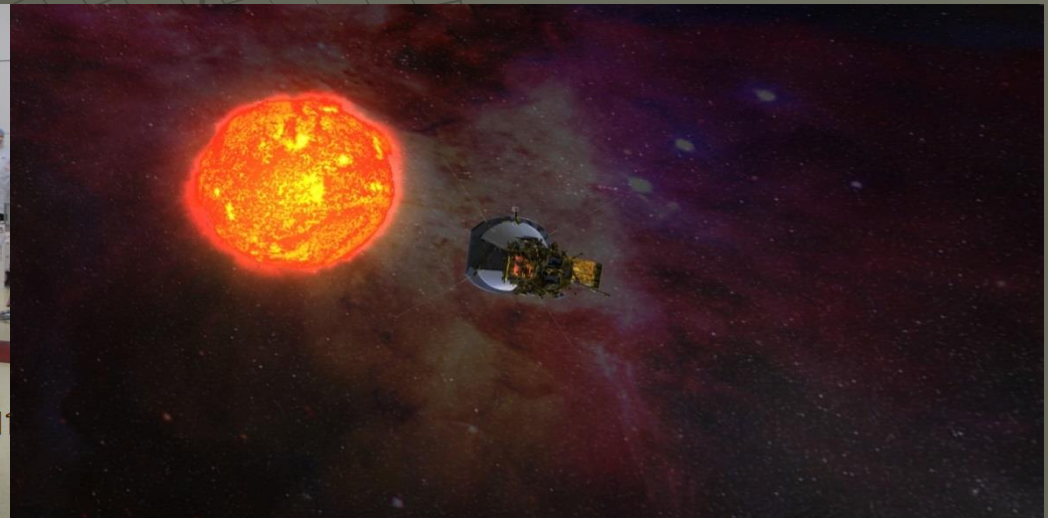
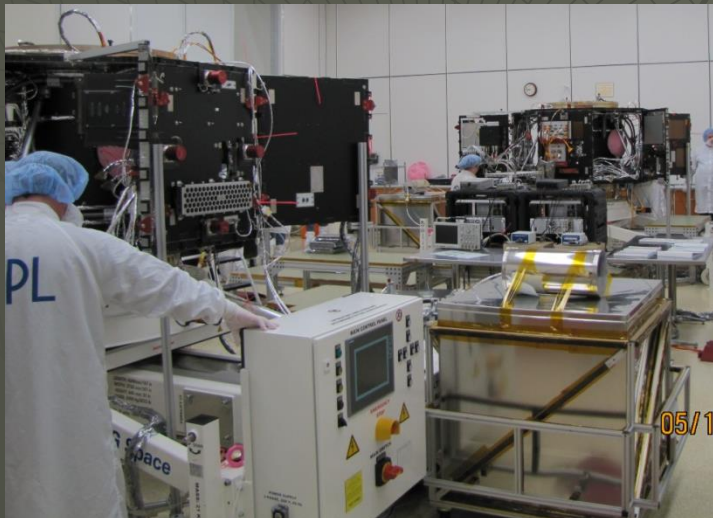
# TFL Mission Support

- ◆ Integration and testing of flight hardware
- ◆ Frequency reference for spacecraft ranging and communications
- ◆ Time-stamping of ground receipt telemetry packets
- ◆ R & D of time and frequency devices and distribution systems



# Support of APL Space Science Missions

- ◆ Continued mission operations support for:
  - TIMED – **T**hermosphere **I**onosphere **M**esosphere **E**nergetics and **D**ynamics
  - STEREO – **S**olar **T**errestrial **R**elations **O**bservatory
  - New Horizons - mission to Pluto and Kuiper Belt Objects
  - MESSENGER – **M**ercury **S**urface, **S**pace **E**nvironment, **G**eochemistry, and **R**anging
  - Van Allen Probes - (formally Radiation Belt Storm Probes), launched Aug 2012
- ◆ Integration support for Solar Probe Plus starts in late 2015

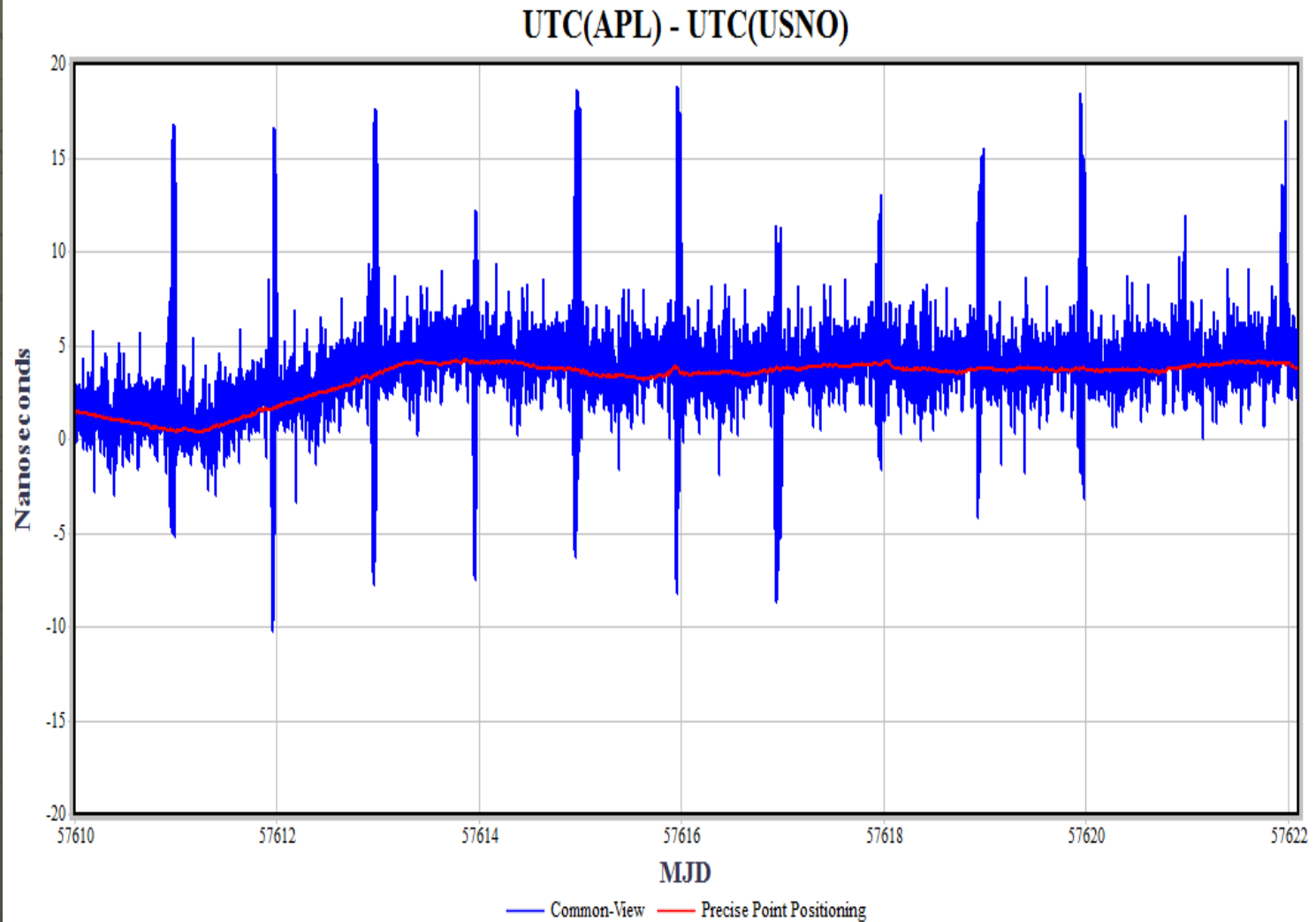


# Time Transfer w/Other U.S. Labs

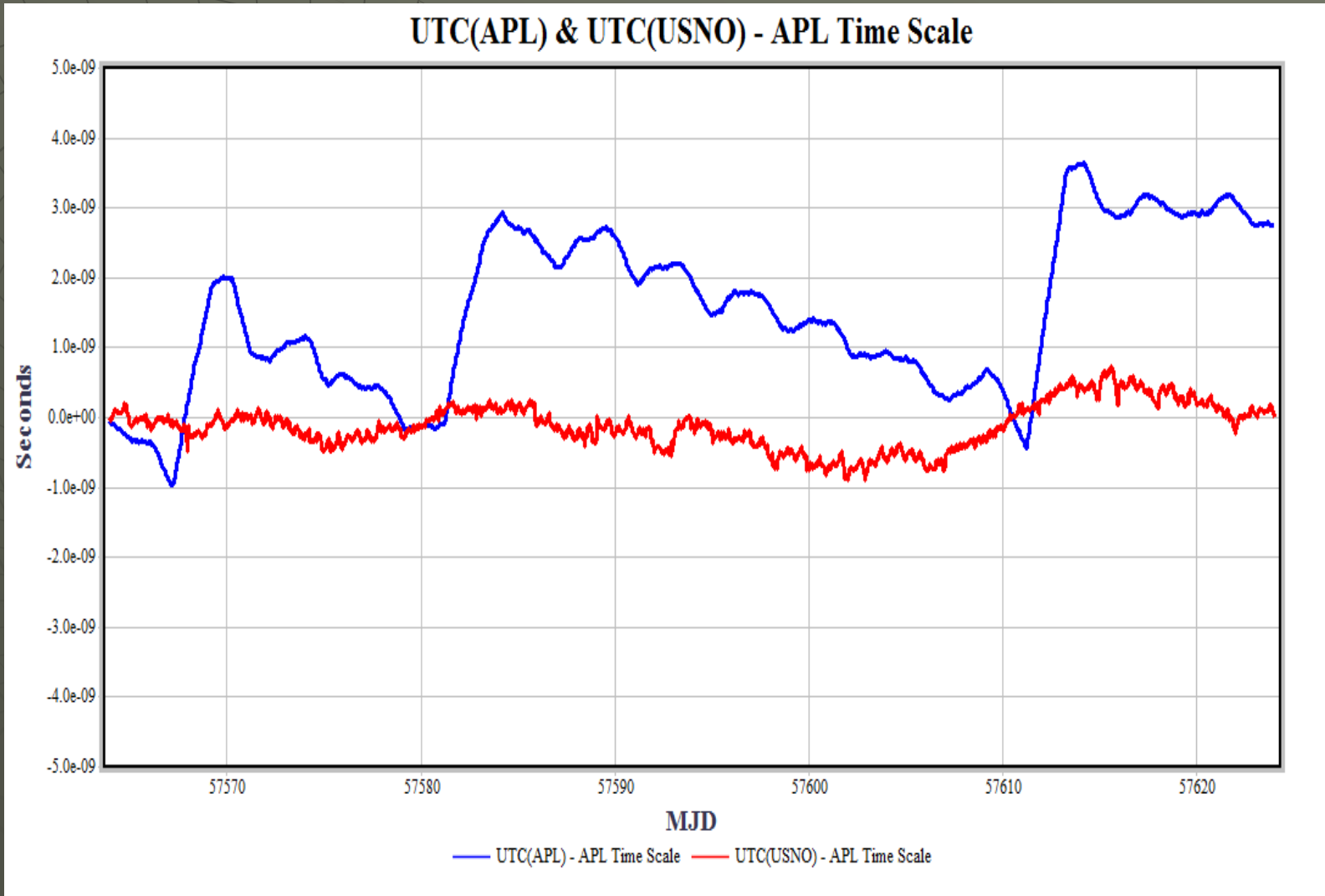
- ◆ Traceability with USNO and NIST has traditionally been done using Common View Time Transfer.
- ◆ Recently APL has started using GPS Carrier Phase time transfer to augment traceability to the USNO
  - ◆ Precise Point Position (PPP) software and license acquired from Canadian National Research Council (NRC).
  - ◆ APL RINEX files generated by a NovAtel Propac6 GPS receiver
  - ◆ USNO RINEX files downloaded from the BIPM
  - ◆ Overlapping three-day solutions computed daily
  - ◆ Only the Backward Solution is retained
  - ◆ APL developed software corrects day cross-over ambiguities



# Common View vs. Carrier Phase Time Transfer

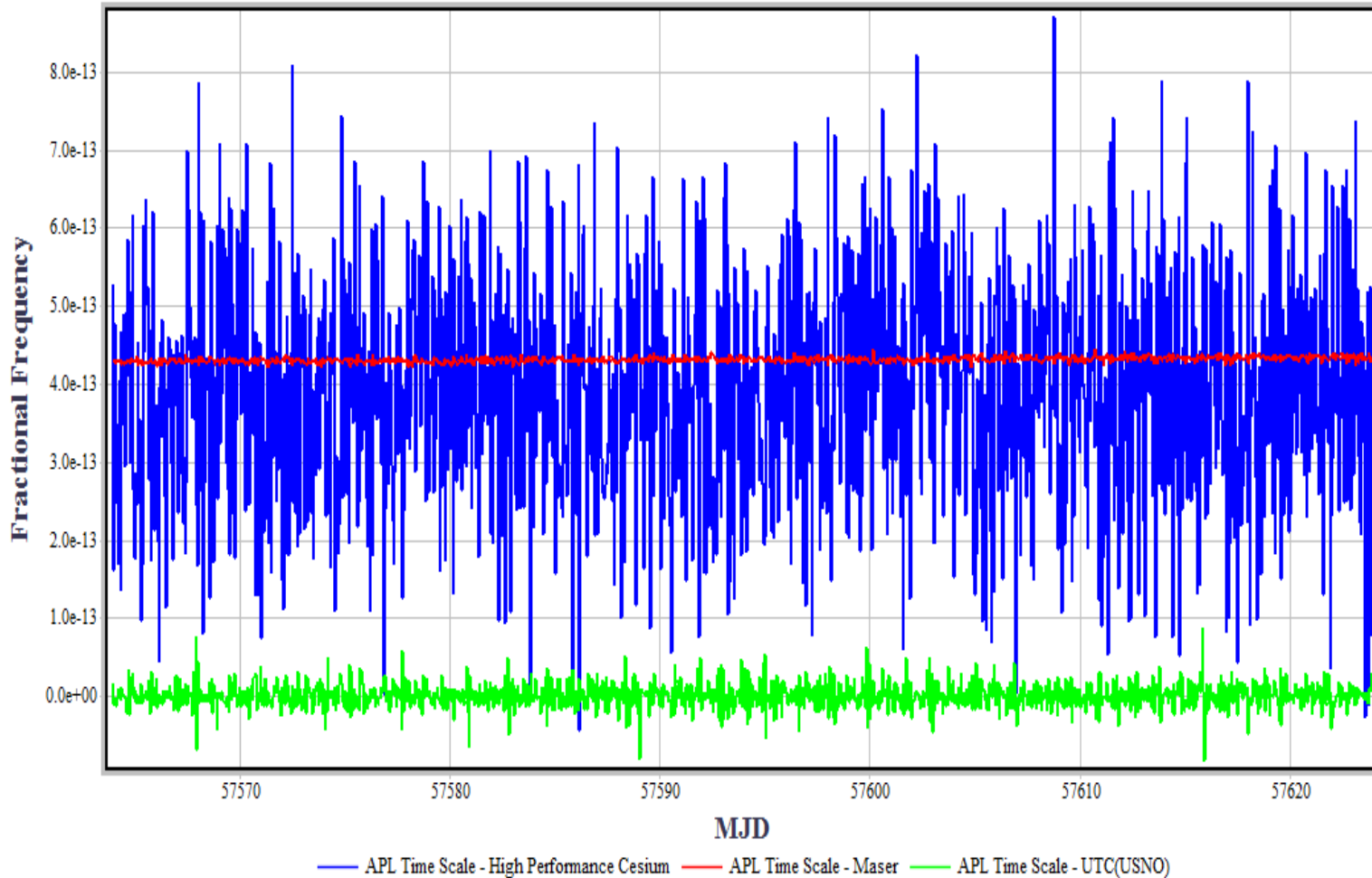


# UTC(APL) and UTC (USNO)\* Relative Time Accuracy



# APL Clocks and UTC (USNO)\* Relative Frequency Stability

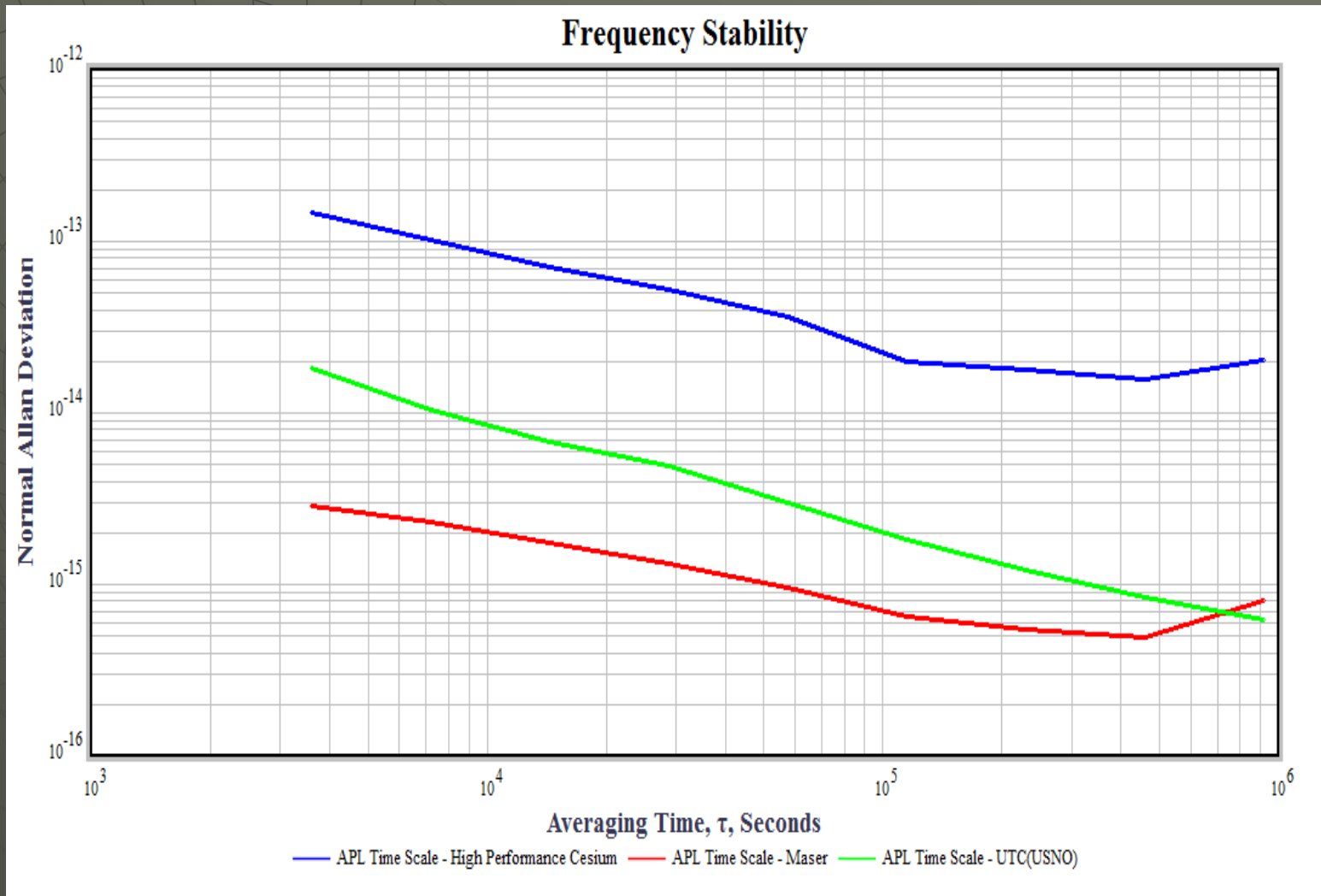
APL Time Scale - High Performance Cesium, Maser, UTC(USNO)



\* Via Carrier Phase Time Transfer



# APL Clocks and UTC(USNO)\* Relative Frequency Stability



# Carrier Phase Summary

- ◆ Can be done with any Lab that generates GPS RINEX data and deposits the data at the BIPM.
- ◆ The UTC(Lab) reference could be used as an additional clock in the ensemble if stable and has near maser precision.
- ◆ Efforts on-going to strengthen the APL Time Scale and improve traceability with other Labs.



Thank You