Modeling NASA/SLR Multi-Photon Receive Energies

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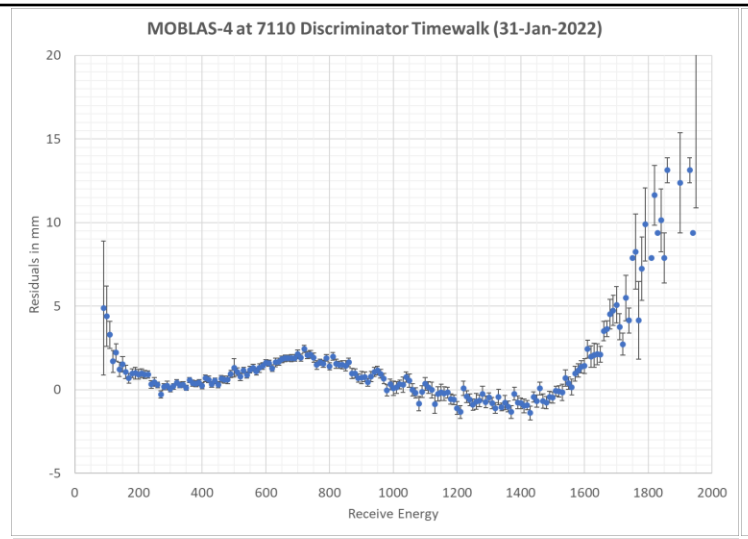
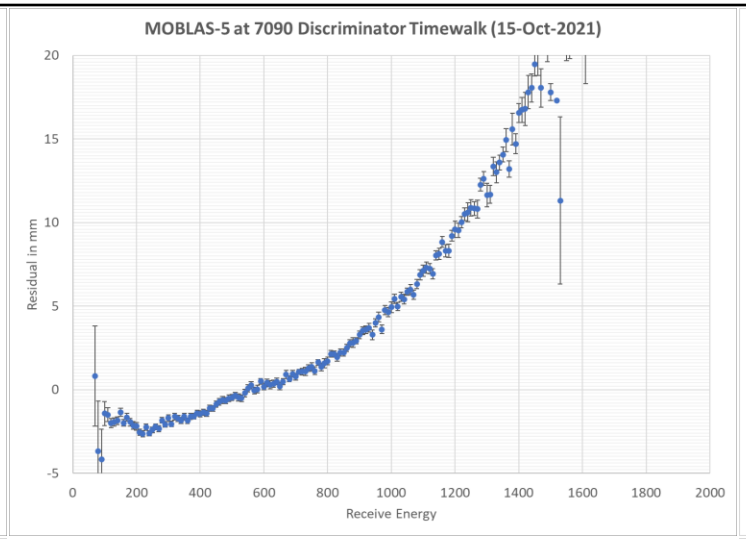
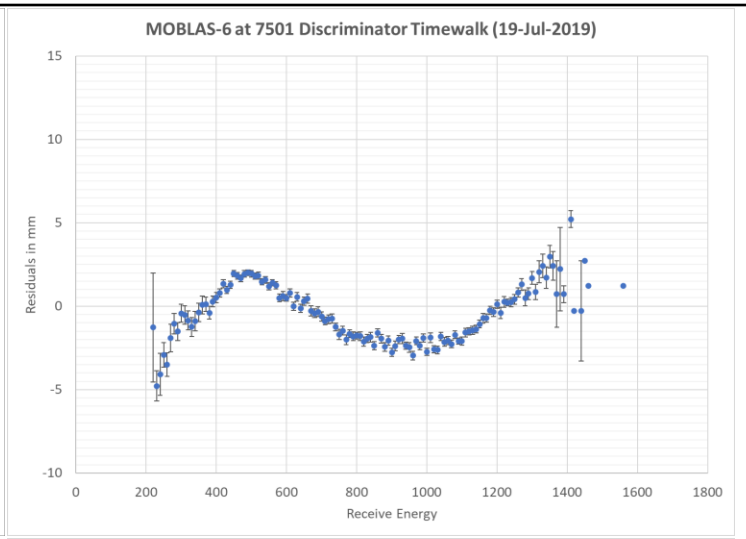
Questions to be Answered

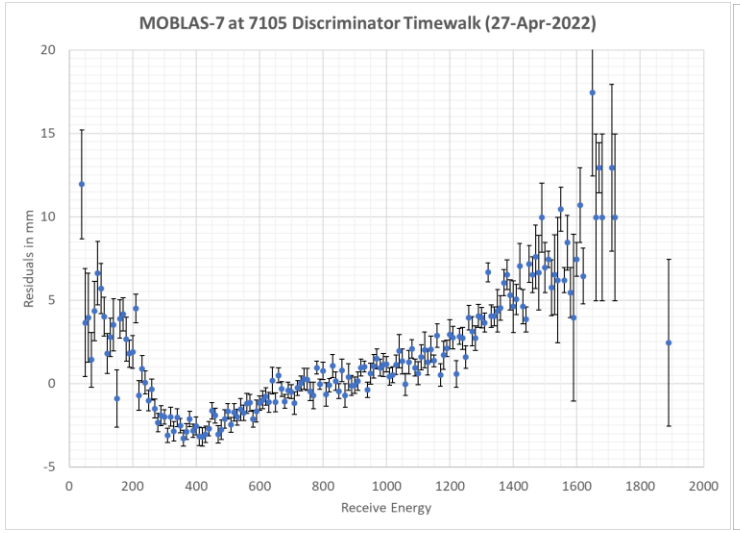
- Do NASA MOBLAS and TLRS receive signal strengths vary by station?
- Are receive amplitude variations elevation/range dependent?
- If we model receive amplitude variations, is there any evidence of LAGEOS satellite signature?
- Does modeling receive energy impact the mean LAGEOS range bias?
- What are the risks to modeling receive amplitude?

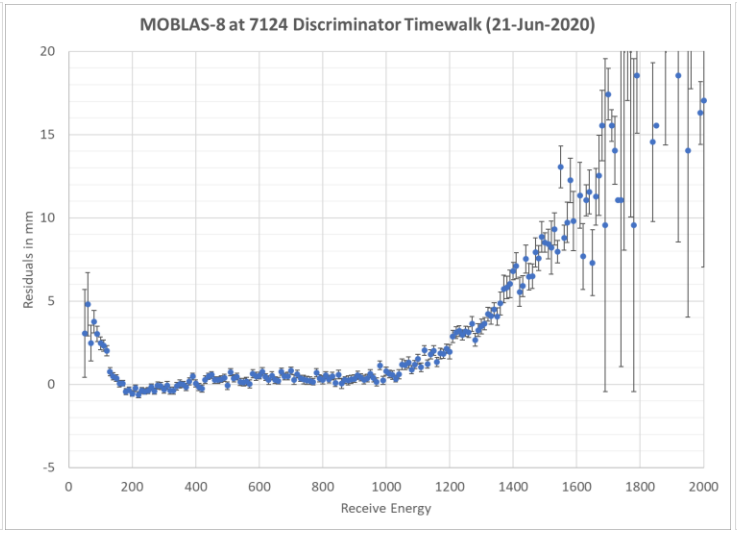
NASA SLR Receive Amplitude Dependence

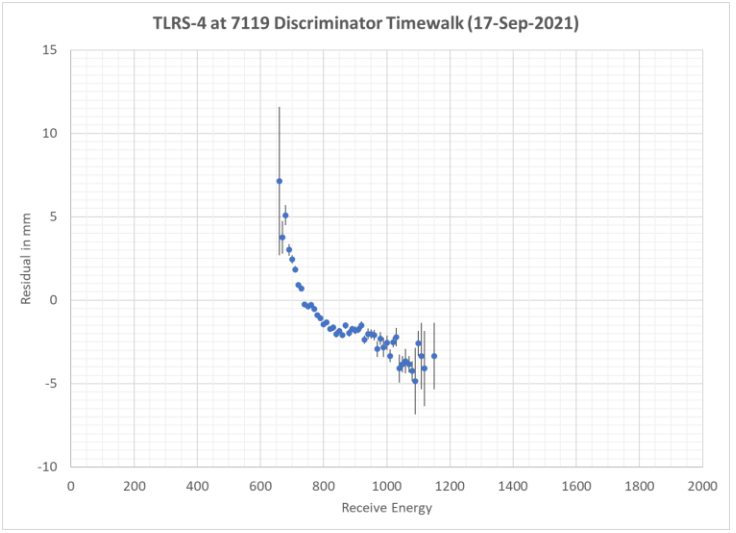






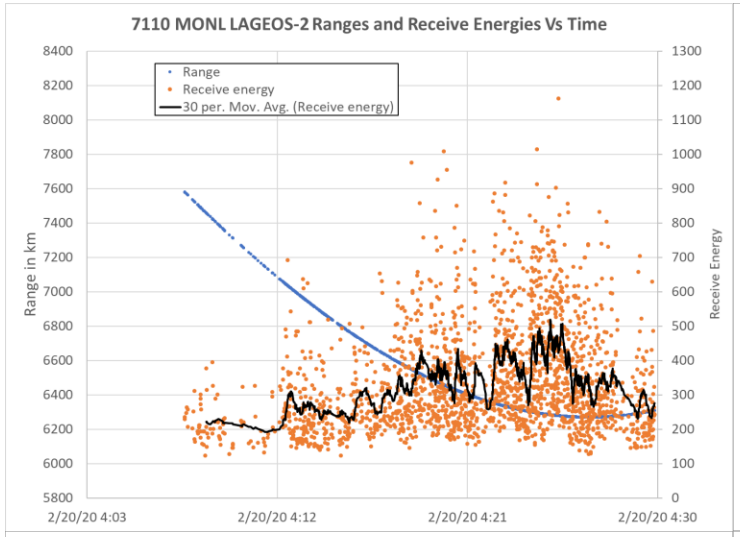


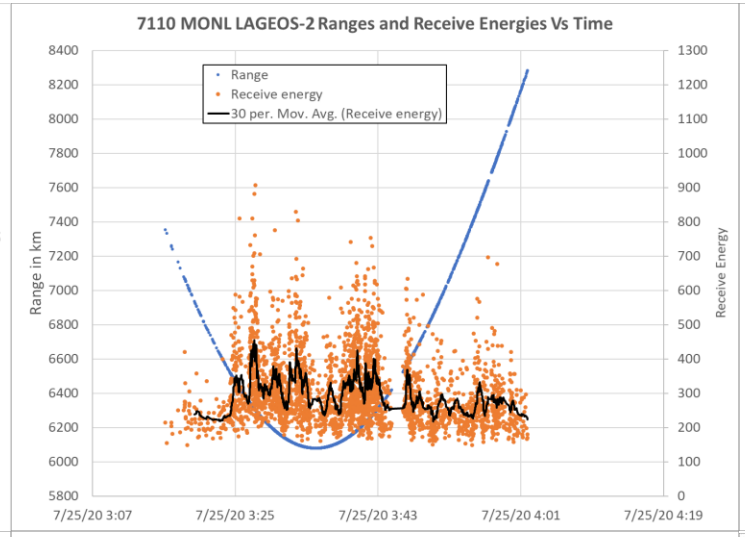


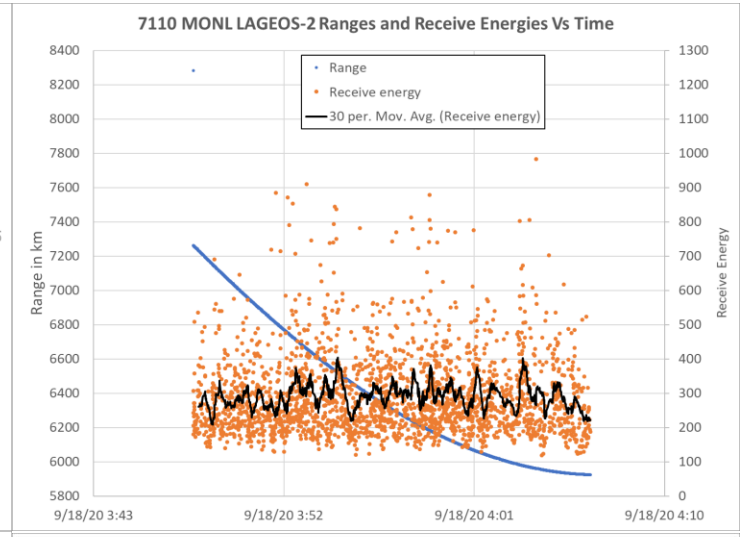


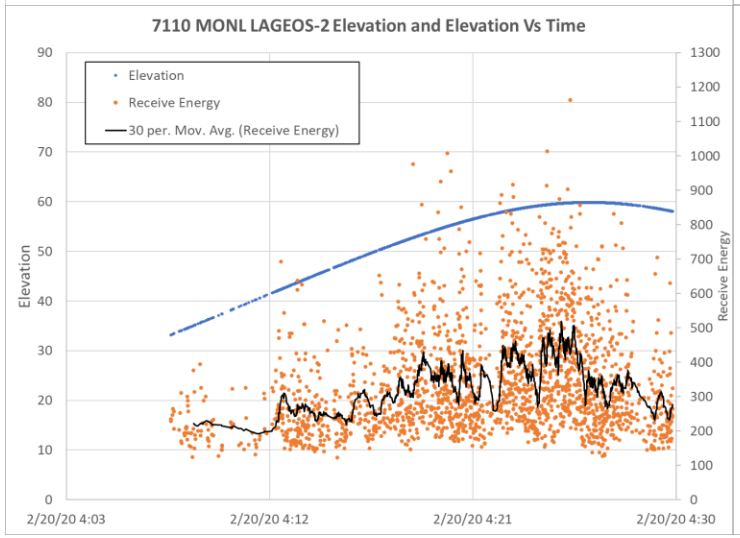
- **The NASA SLR systems employ two cascading discriminators to minimize timewalk in its Constant Fraction Discriminators (CFDs). CFDs trigger on the centroid of the received pulse. The receive energy is measured by a quad integrator and is the area under a curve.**

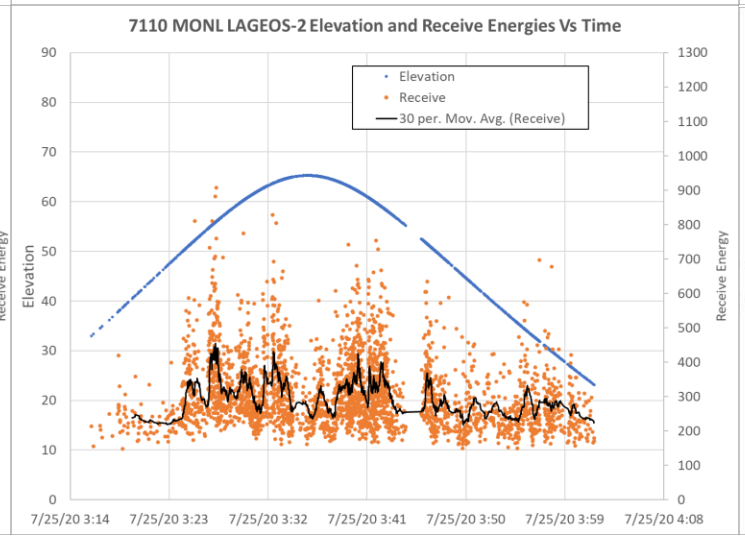
7110 MONL Receive Energies versus Range/Elevation

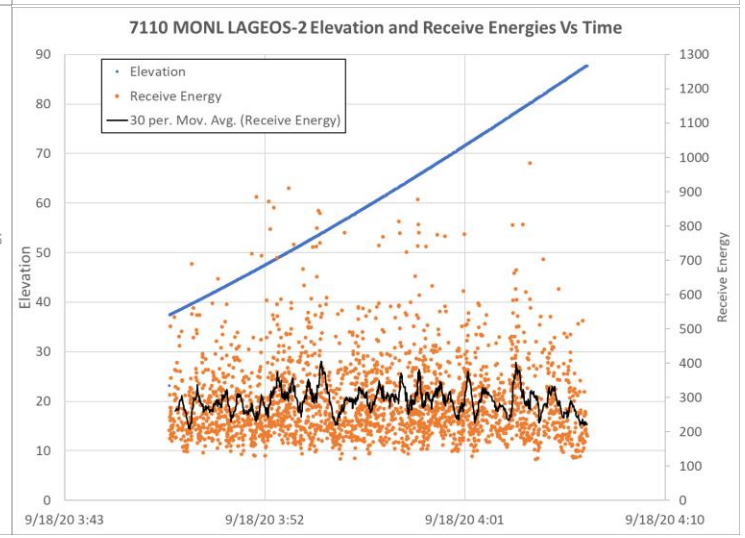






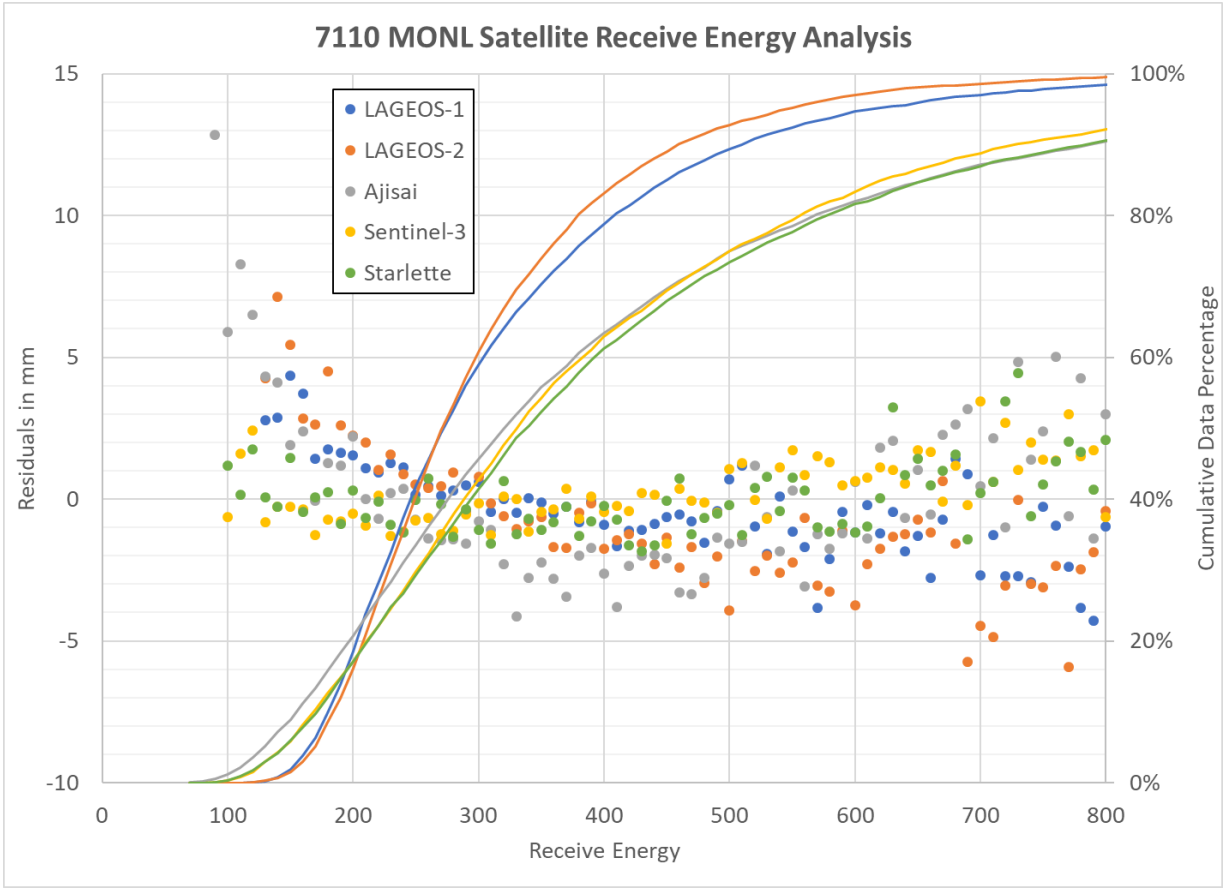






- **Amplitude variations can oscillate through the pass. The strongest signals tend to elevation/range dependent, but not always.**

7110 MONL Satellite Receive Energy Analysis



Sentinel-3: 7 retroreflectors

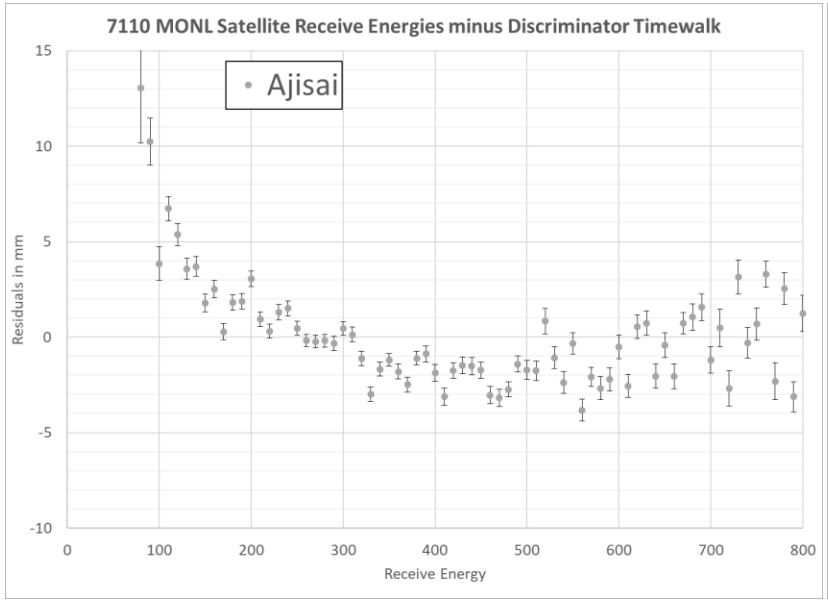
Starlette: 60 retroreflectors

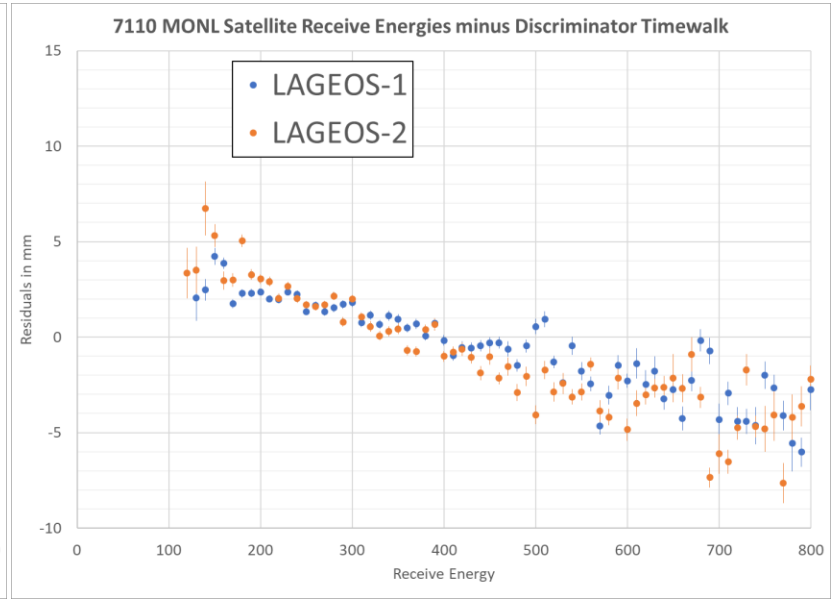
LAGEOS: 426 retroreflectors

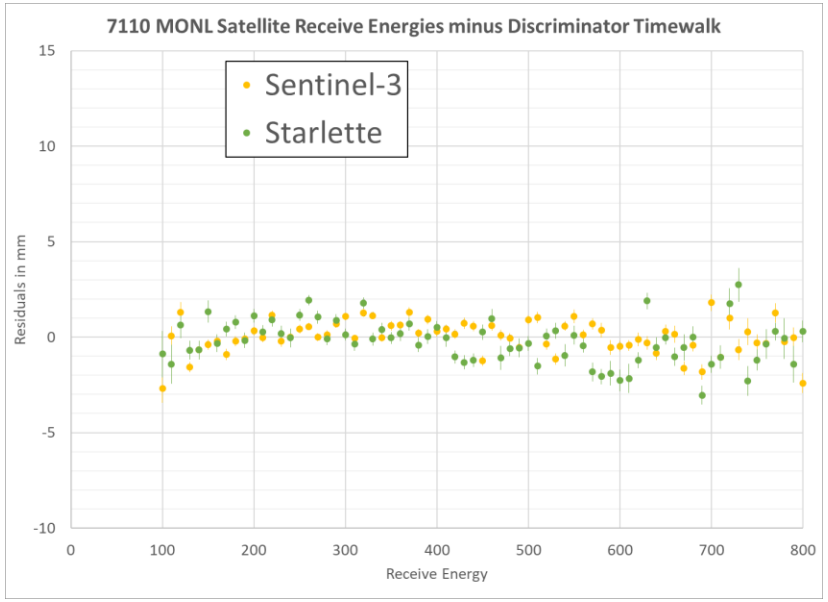
Ajisai: 1436 retroreflectors

- **The chart displays 7110 satellite receive energy variations on the left axes and their cumulative receive energy distributions on the right axes from a sampling of 3 to 4 robust nighttime passes. MONL LAGEOS and LEO data were taken at 5 and 10 Hz; respectively. Greater than 90% of LAGEOS and LEO data have receive energies less than 600 and 800; respectively. On the right are the four satellite retroreflector arrays and their number of retroreflectors.**

7110 MONL Satellite Receive Energy Analysis Post removing the Discriminator Timewalk

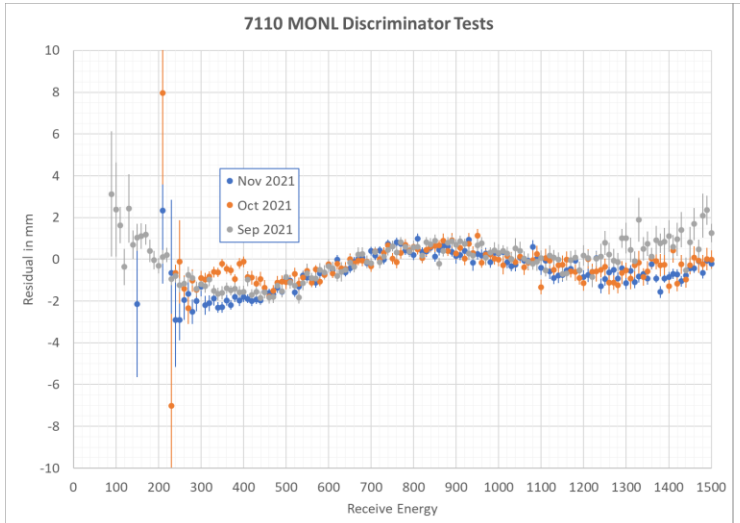


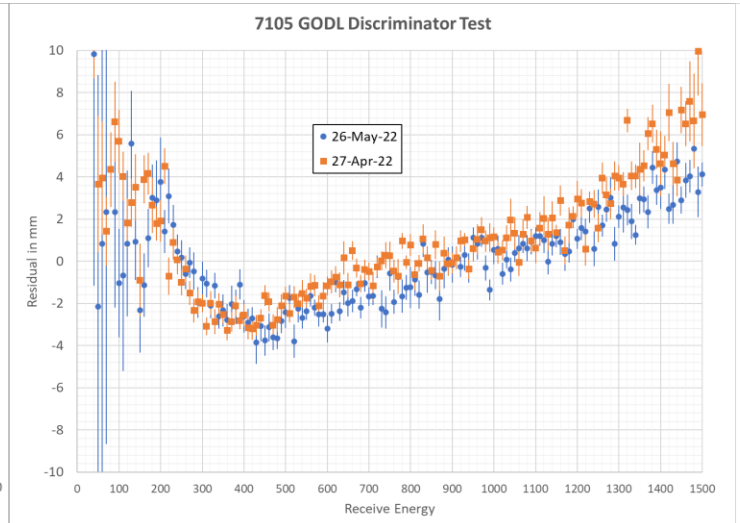


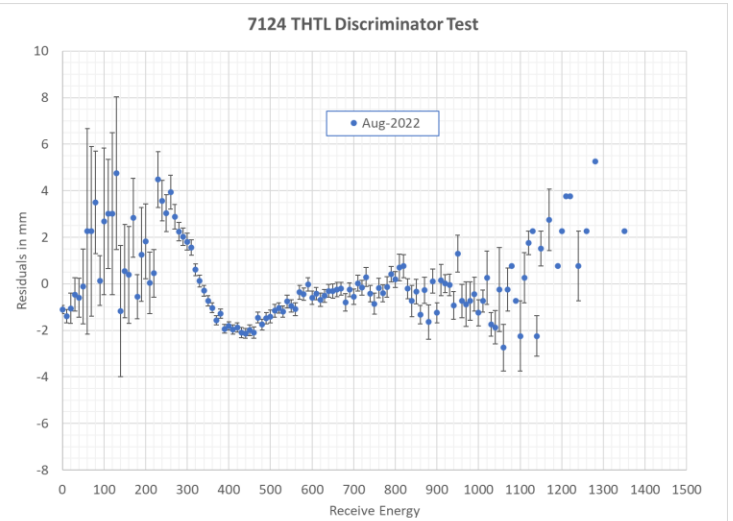


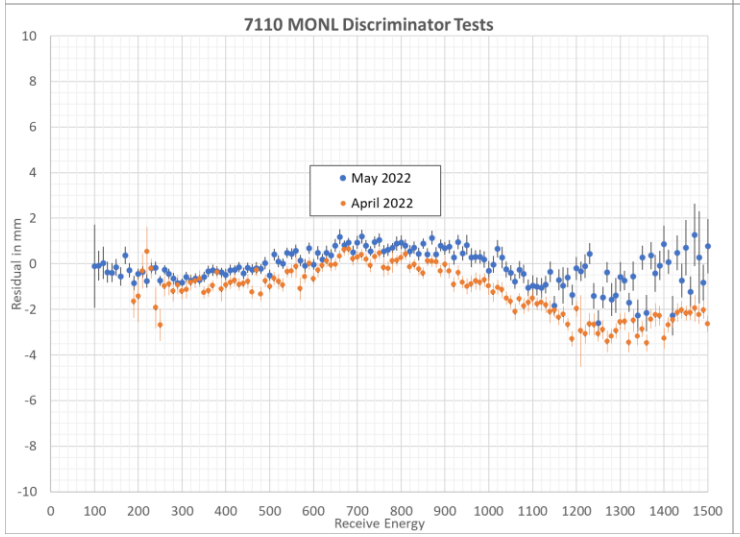
- Here are three charts of 7110 satellite receive energies after removing the receive discriminator timewalk based on the December 2020 discriminator test. The resultant trends from these satellite are different based on the complexity of the retroreflector arrays.
- Are we now seeing the Ajisai and LAGEOS satellite signatures; something else; or was there a flaw in modeling the receive energy variations?
- When applying the 7110 MONL discriminator curve to both calibration and LAGEOS-1 and LAGEOS-2 data, the mean range changed less than 1 mm.

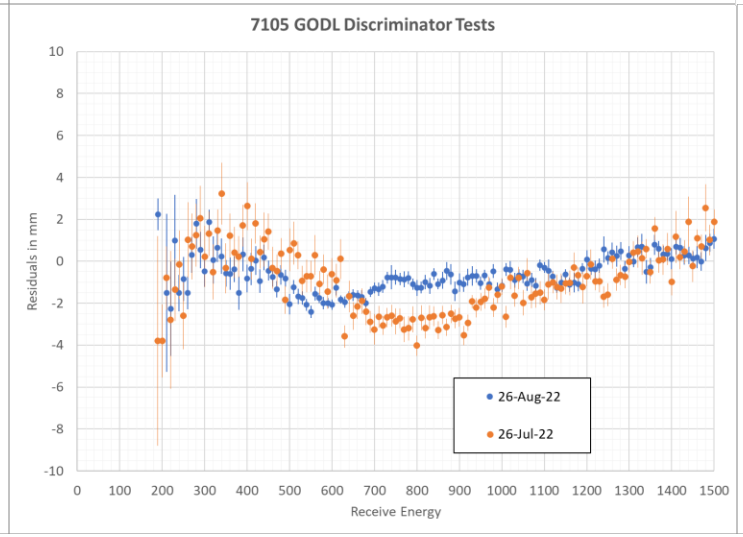
Barriers to Modeling Receive Energy Variations

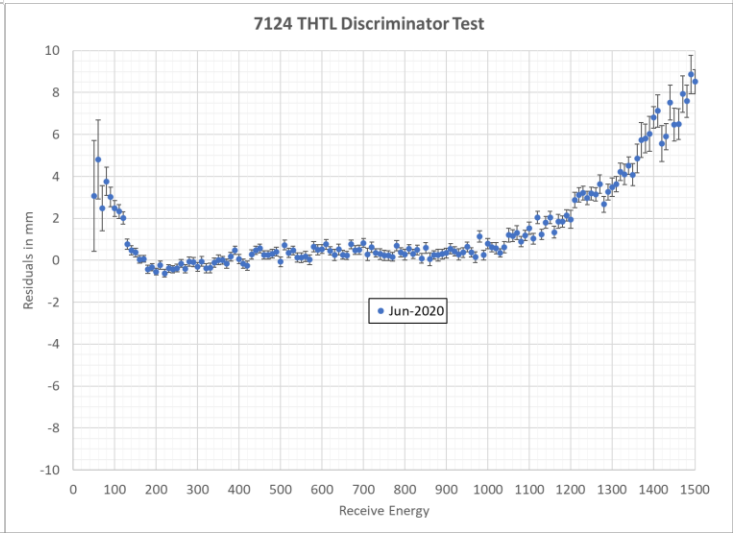






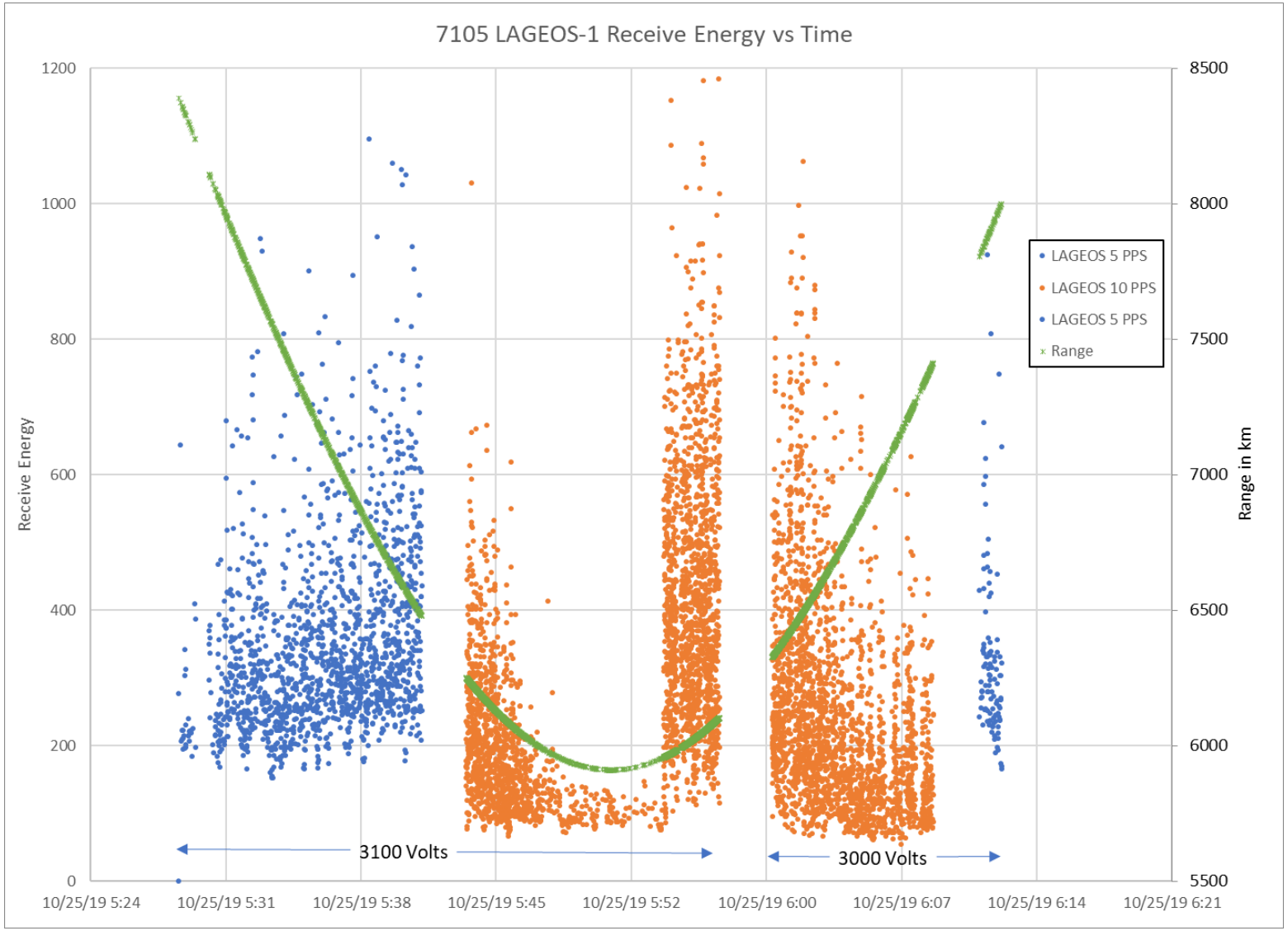






- **Discriminator curves may change overtime. Top right chart: receive energies less than 250 appear suspect.**

Receive Energy Variations between 5 and 10 Hz



- A time series of 7105 GODL shot-by-shot receive energies (left axes) and ranges (right axes) from a high elevation pass.
- For some unknown reason, when ranging to LAGEOS at 10 Hz, the receive energies measure less by ~100 units than when ranging at 5 Hz

Original Questions and Answers

- Do NASA MOBLAS and TLRS receive signal strengths vary by station? Yes
- Are receive amplitude variations elevation/range dependent? Sometimes, pass dependent
- If we model receive amplitude variations, is there any evidence of LAGEOS satellite signature? Yes
- Does modeling receive energy impact the mean LAGEOS range bias? Inconclusive based on only results from one station
- What are the risks to implementing modeling receive amplitude? The measurement is sometimes unavailable/unreliable; the timewalk characteristics for a given station can change; and the receive energy differences between 5 and 10 Hz LAGEOS ranging are not understood