

# Spoofing of GNSS positioning

## Autonomous vehicles and its Vulnerability to spoofing\*

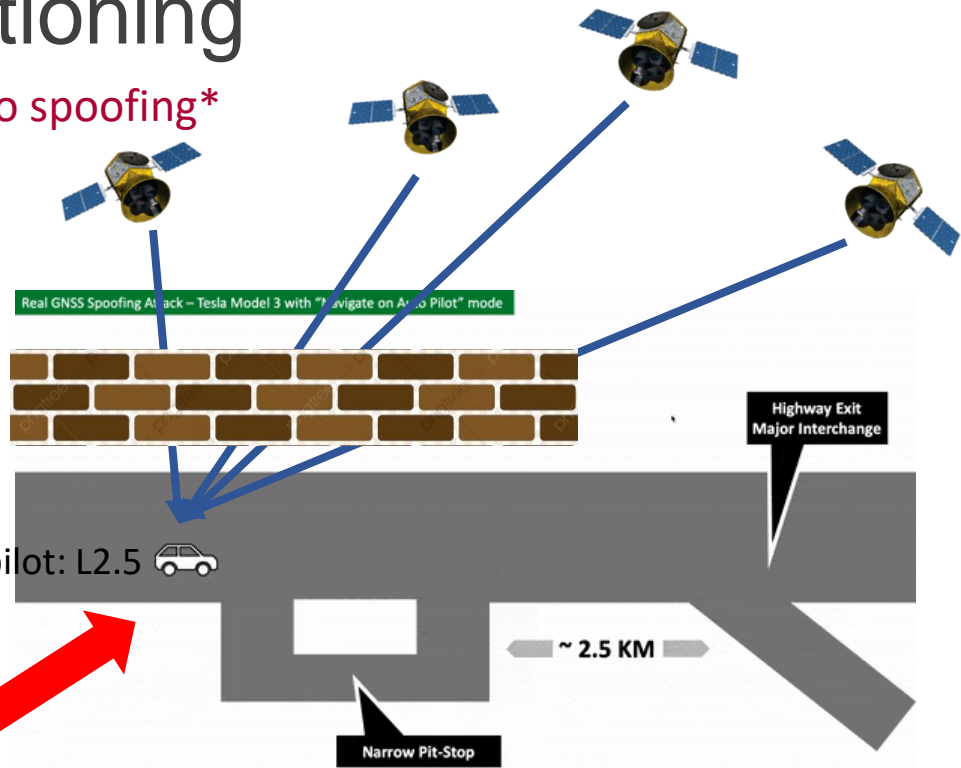
- ❑ Autonomous vehicles heavily rely on GNSS
- ❑ GNSS is vulnerable to spoofing



Jammer



Spoofers

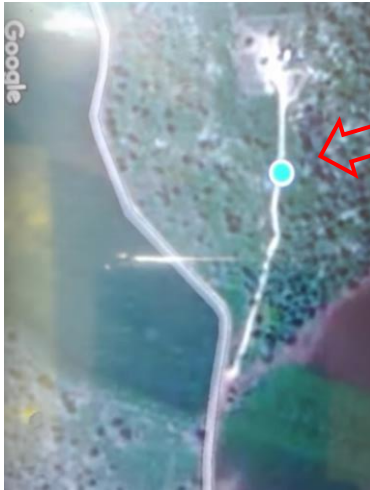


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\*Tesla Model 3 Spoofed off the highway. Available online: <https://www.regulus.com/blog/tesla-model-3-spoofed-off-the-highway-regulus-researchers-hack-navigation-system-causing-car-to-steer-off-road/>

# Autonomous vehicles and its Vulnerability to spoofing

- ❑ The car is only using GPS and map data to determine what lanes it should be in and what exits to take.

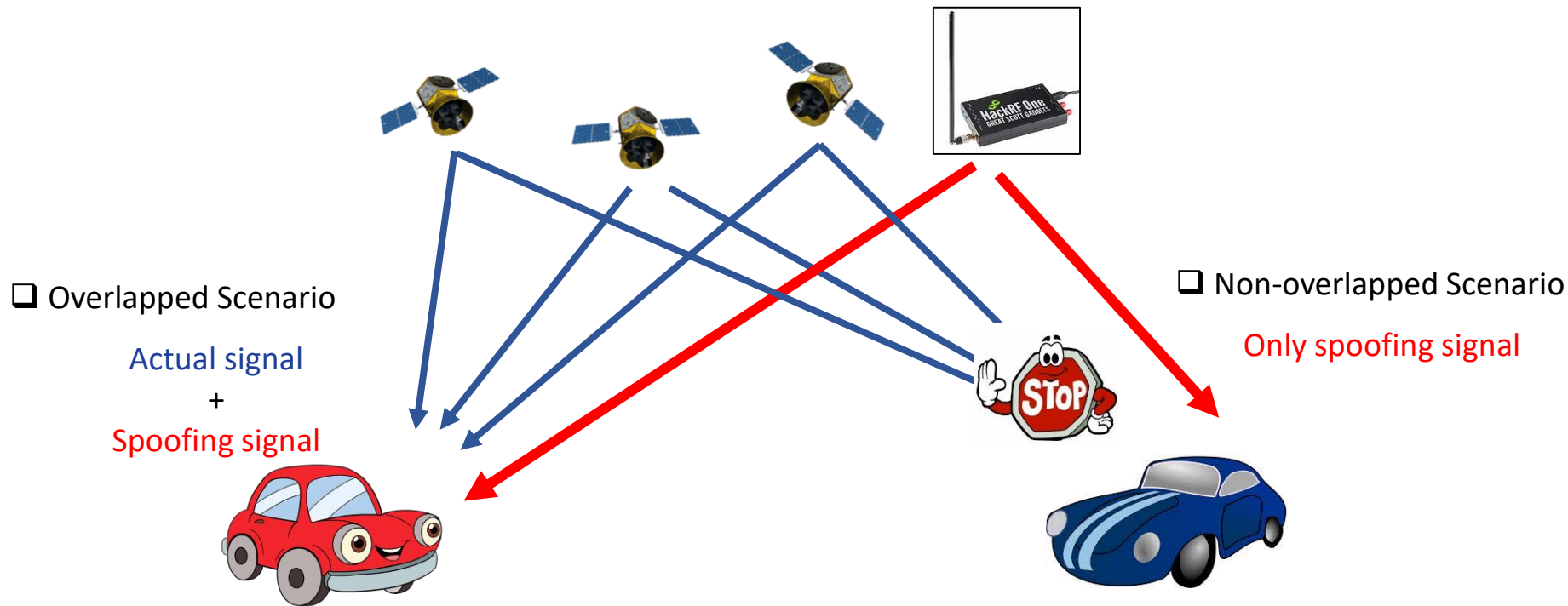


**Anti-spoofing is critical to autonomous vehicle navigation !**

\*Tesla Model 3 Spoofed off the highway. Available online: <https://www.regulus.com/blog/tesla-model-3-spoofed-off-the-highway-regulus-researches-hack-navigation-system-causing-car-to-steer-off-road/>

# Popular GNSS Spoofing Methods

## Overlapped and Non-overlapped spoofing



Meng, Q., Hsu, L.T.\*, Xu, B., Luo, X., El-Mowafy, A., (2019) [A GPS Spoofing Generator using an Open Sourced Vector Tracking-Based Receiver](#), Sensors, 19 (18):3993.

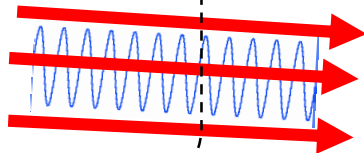
# GNSS Spoofing Methods

## Spoofing signal generation

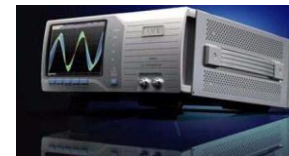
### Meaconing



$+\Delta t$



### Simulator-based



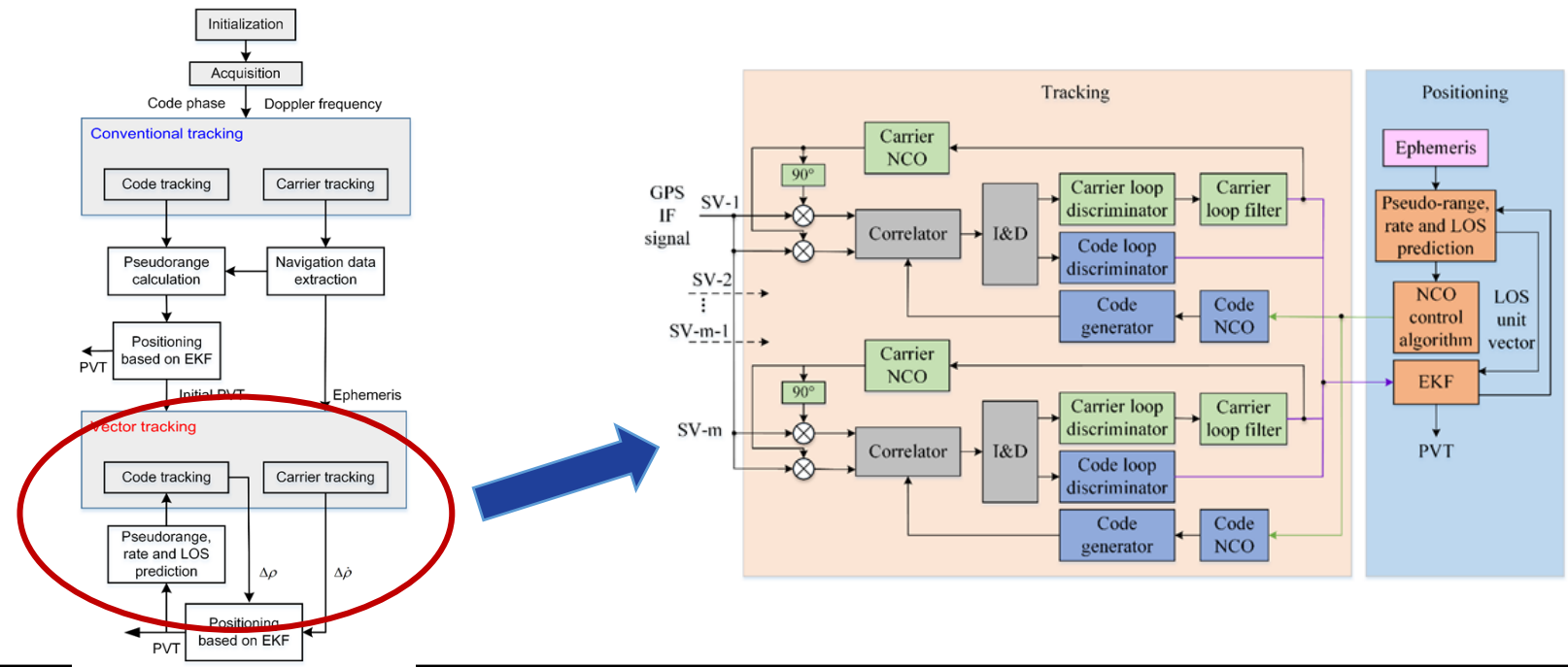
### Software-defined receiver



Meng, Q., Hsu, L.T.\*, Xu, B., Luo, X., El-Mowafy, A., (2019) [A GPS Spoofing Generator using an Open Sourced Vector Tracking-Based Receiver](#), Sensors, 19 (18):3993.

# 2. Spoofing generator using Vector tracking

Implementation based on Open sourced software-defined receiver\*†



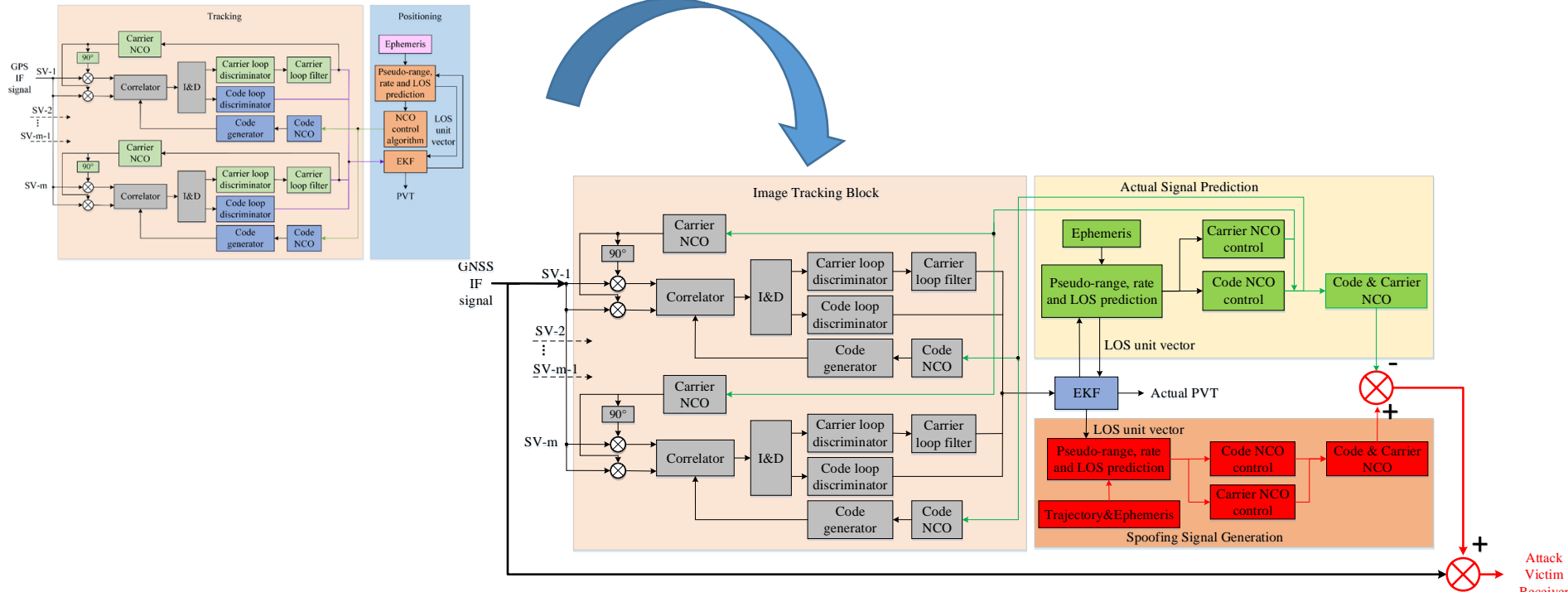
\*Xu, B.; and Hsu, L.T. Open-source MATLAB code for GPS vector tracking on a software-defined receiver. *GPS solutions*, 2019, 23(2), 46.

†GPS Toolbox link : [https://www.ngs.noaa.gov/gps-toolbox/GPS\\_VT\\_SDR.htm](https://www.ngs.noaa.gov/gps-toolbox/GPS_VT_SDR.htm)



# Proposed Spoofing generator using Vector tracking

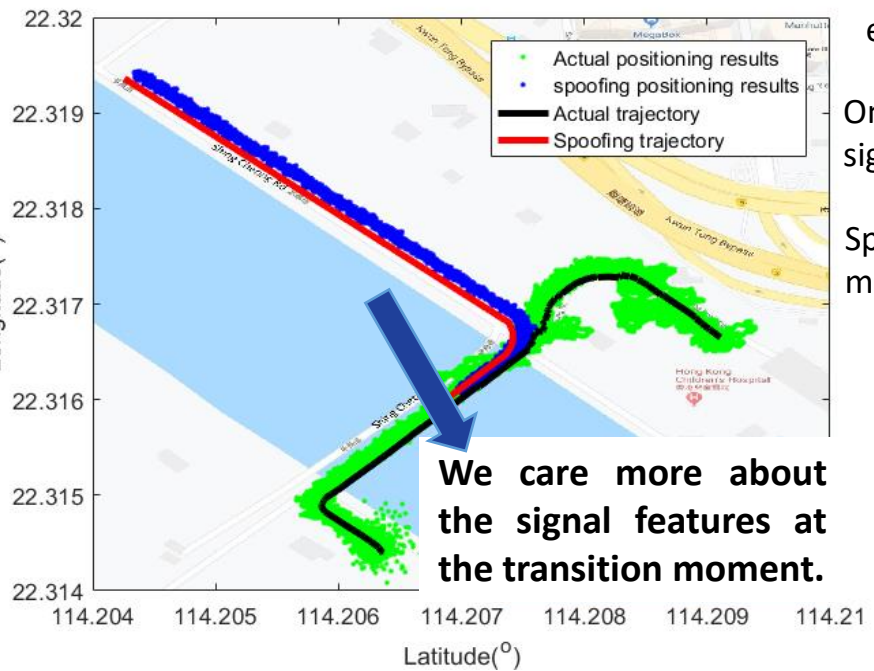
## Spoofing generator based on Vector-tracking SDR



Meng, Q., Hsu, L.T.\*, Xu, B., Luo, X., El-Mowafy, A., (2019) [A GPS Spoofing Generator using an Open Sourced Vector Tracking-Based Receiver](#), Sensors, 19 (18):3993.

# 4. Experiment and Discussion

## Performance in positioning results

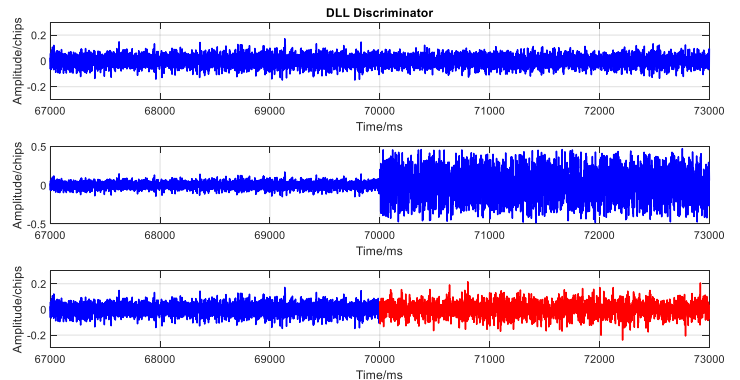


**We care more about the signal features at the transition moment.**

Meng, Q., Hsu, L.T.\*, Xu, B., Luo, X., El-Mowafy, A., (2019) [A GPS Spoofing Generator using an Open Sourced Vector Tracking-Based Receiver](#), Sensors, 19 (18):3993.

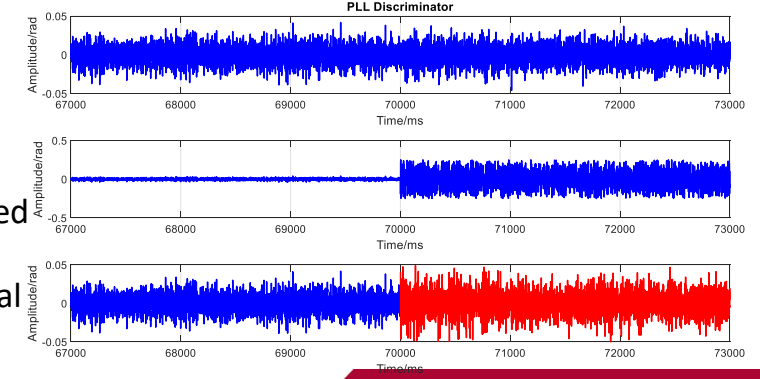
### delay lock loop (DLL)

No attacks exist  
Only actual signal cancelled  
Spoofing signal modulated



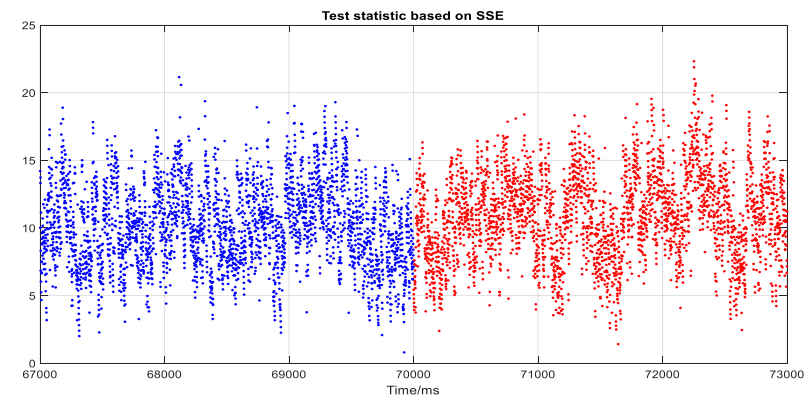
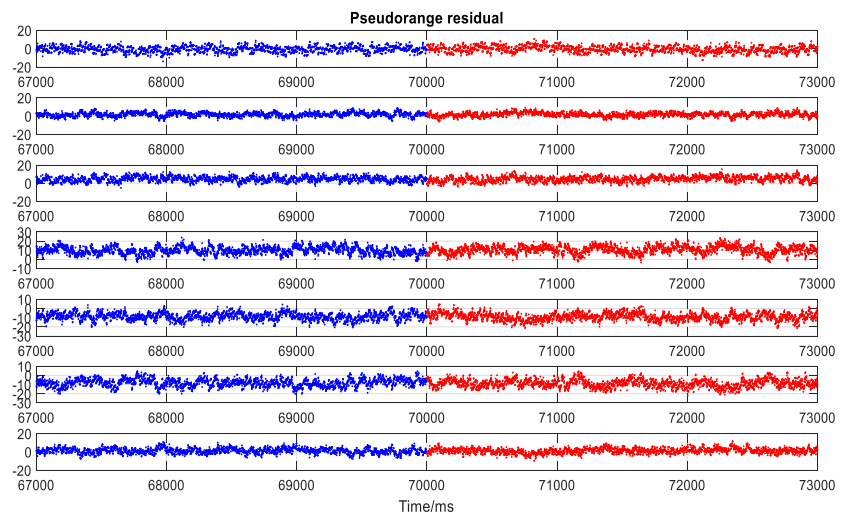
### phase lock loop (PLL)

No attacks exist  
Only actual signal cancelled  
Spoofing signal modulated

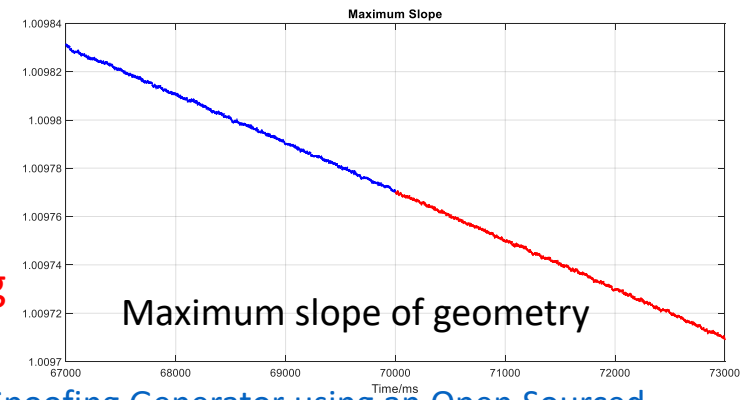


# 4. Experiment and Discussion

## Performance in observations



Test statistics based on sum of the squares of the residual errors (SSE).



Pseudorange residuals in every tracking channels  
Consistency check fails to detect this kind of spoofing

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