FINAL REPRESENTATION
–Mobilephone Experiment

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OUTLINE

- Introduction
- Experiments - TCP HO
- Observations
- Difficulties
- Conclusions
- Appendix

INTRODUCTION

The First Half Semester

TCP HO Observations:

- Read the paper - 5G Measurement, Performance on MRT

- Get familiar with the tools and codes

- Try to let server and the phone communicate

- Plot the TCP RTT of the dormitory

The Second Half Semester

TCP HO Observations:
- Get the data - dormitory, scooter, MRT, HSR

- Observe the handover events

- Analyze the observations

ML Prediction:
- Try the ML project
    - Features, parameters

- Help getting datas by taking MRT

Handover Event Type

TABLE I
DESCRIPTION FOR DIFFERENT HANDOVER EVENT TYPES

Event type	Description
eNB handover	(eNB1) → (eNB2)
Inter-Master Node (MN) handover without Secondary Node change	(eNB1, gNB1) → (eNB2, gNB1)
Secondary Node (SN) addition	(eNB1) → (eNB1, gNB1)
Secondary Node (SN) change	(eNB1, gNB1) → (eNB1, gNB2)
Secondary Node (SN) removal	(eNB1, gNB1) → (eNB1)
Inter-Master Node (MN) handover with Secondary Node (SN) change	(eNB1, gNB1) → (eNB2, gNB2)
eNB to Master Node (MN) change	(eNB1) → (eNB2, gNB1)
Master Node (MN) to eNB change	(eNB1, gNB1) → (eNB2)

- LTE HO = eNB HO
- MN HO is the version of without SN change
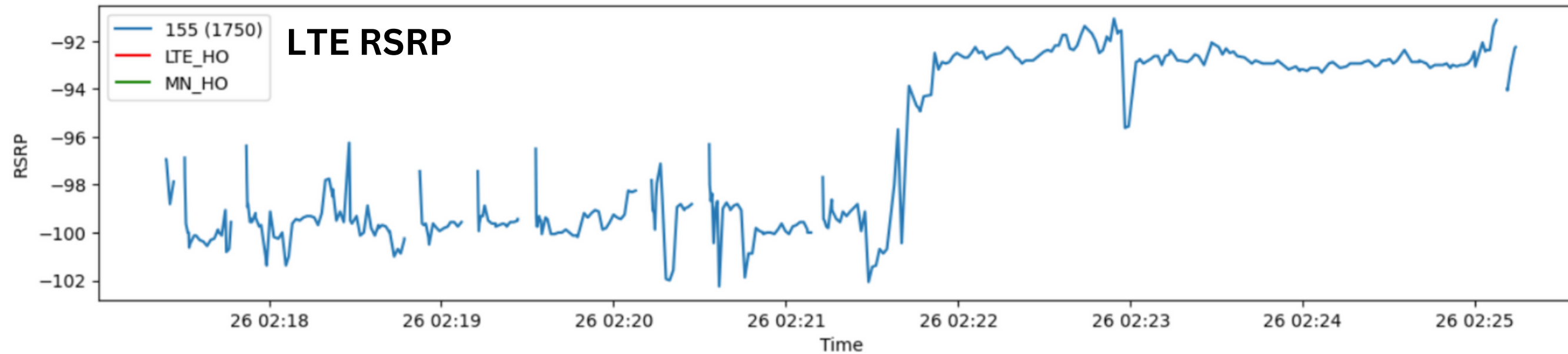- SN Setup = SN addition
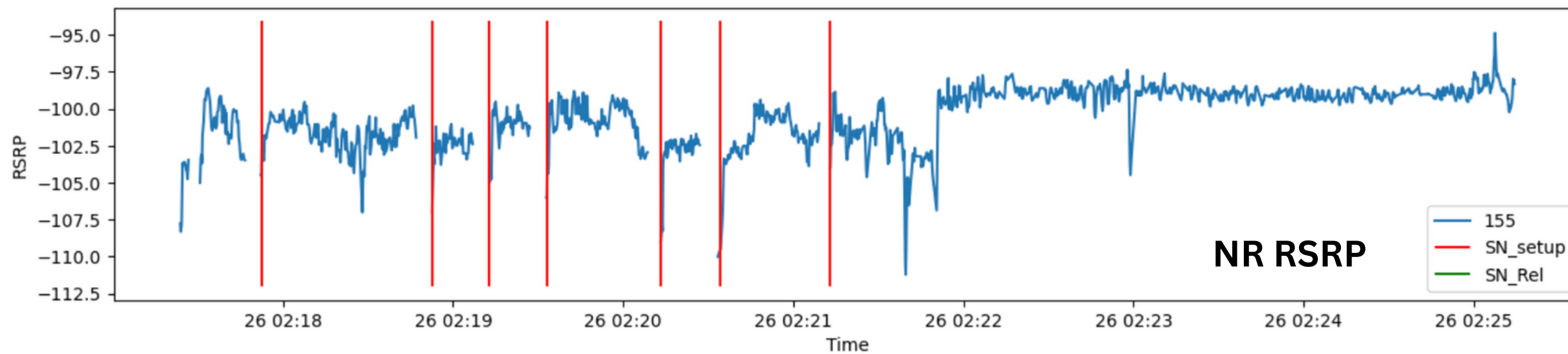- SN Rel = SN release
- SN Req = SN setup

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EXPERIMENTS
–TCP HO

Experiment at the dorm

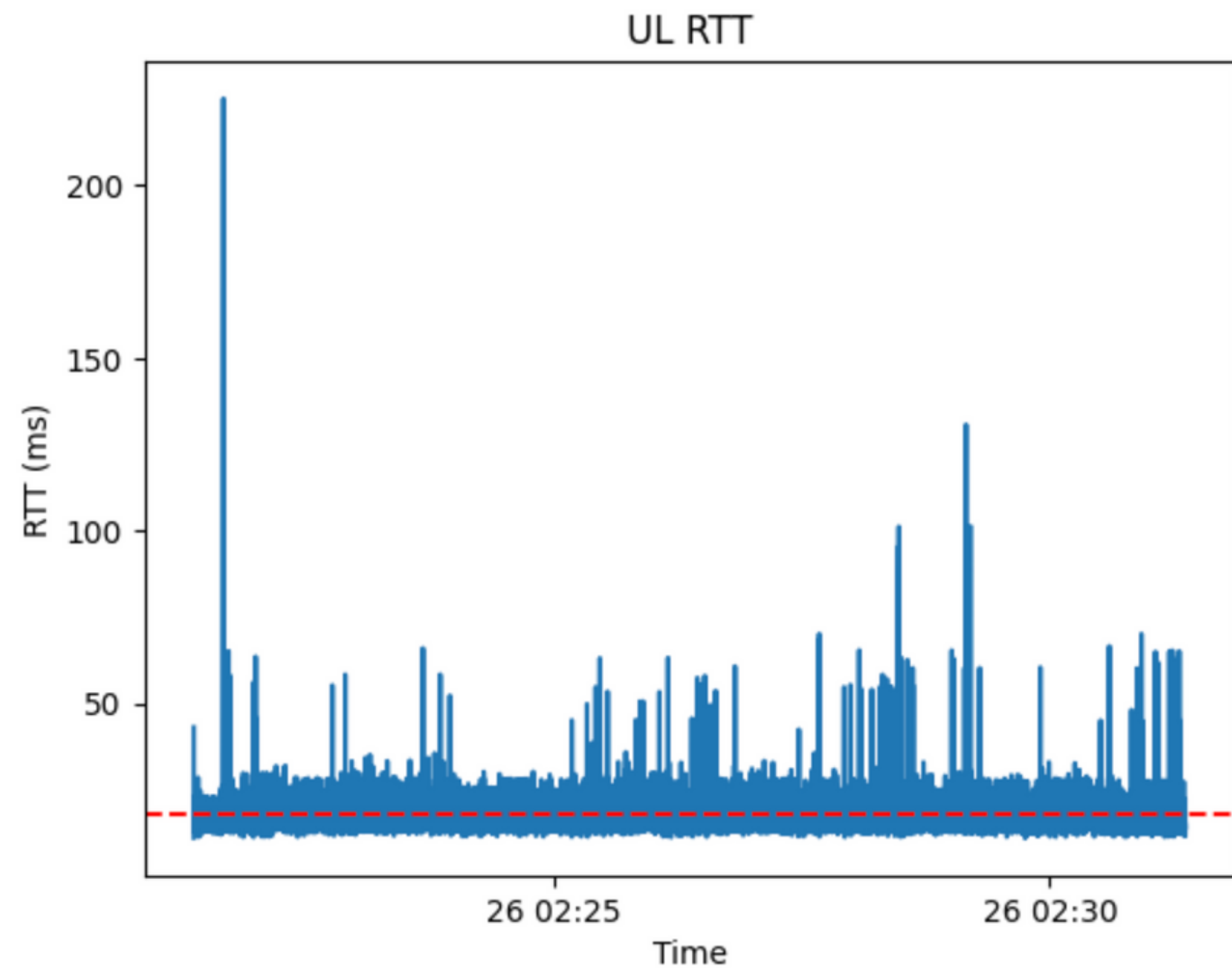**LTE RSRP**

NR RSRP

Condition
- 5 min
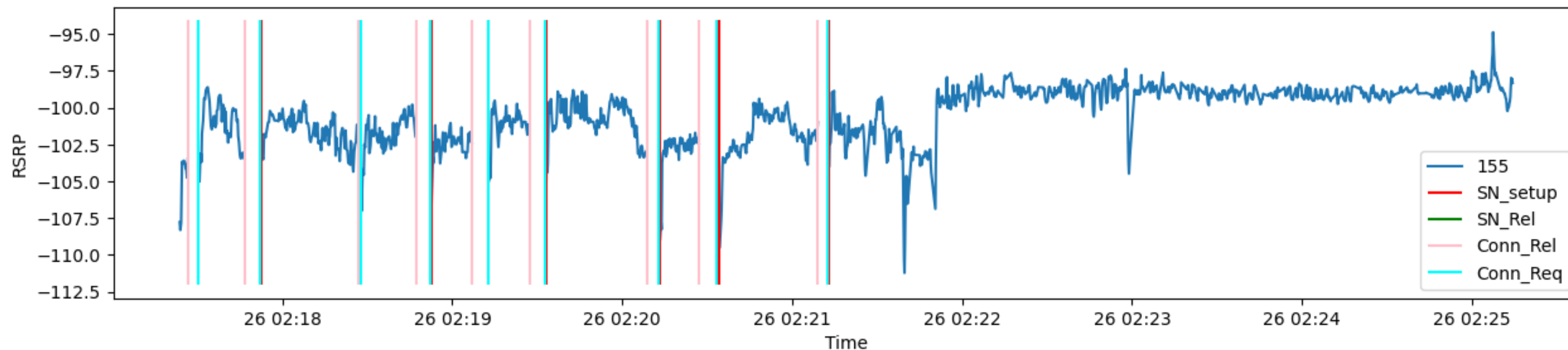- At the dormitory

Discovery
- pci didn't change
- Signal weak when Idle
- A lot of SN setup
  - but no SN rel
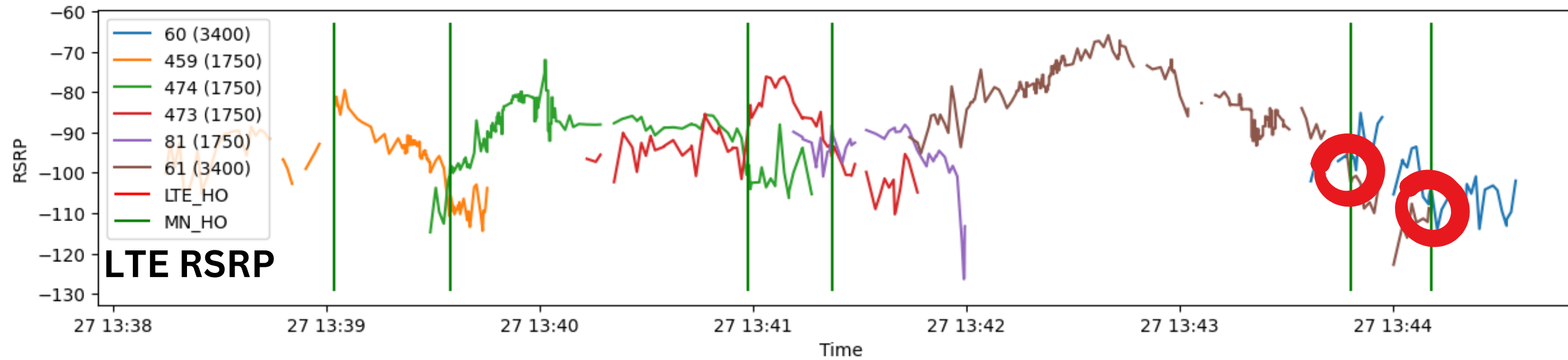
Experiment at the dorm

Discovery

- keep releasing and requesting
- in the idle mode
- not turning on the iperf3
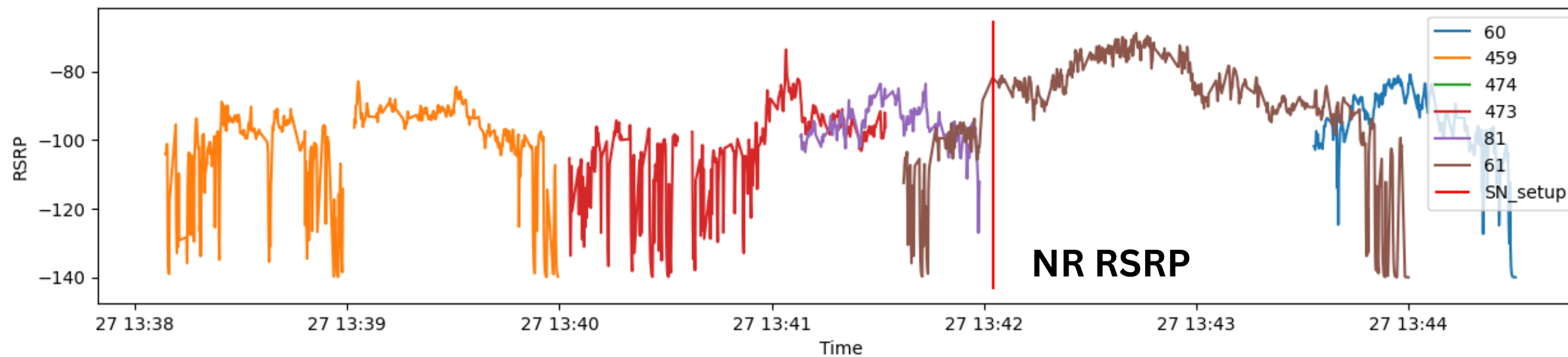- some background app need the internet
  - reconnection
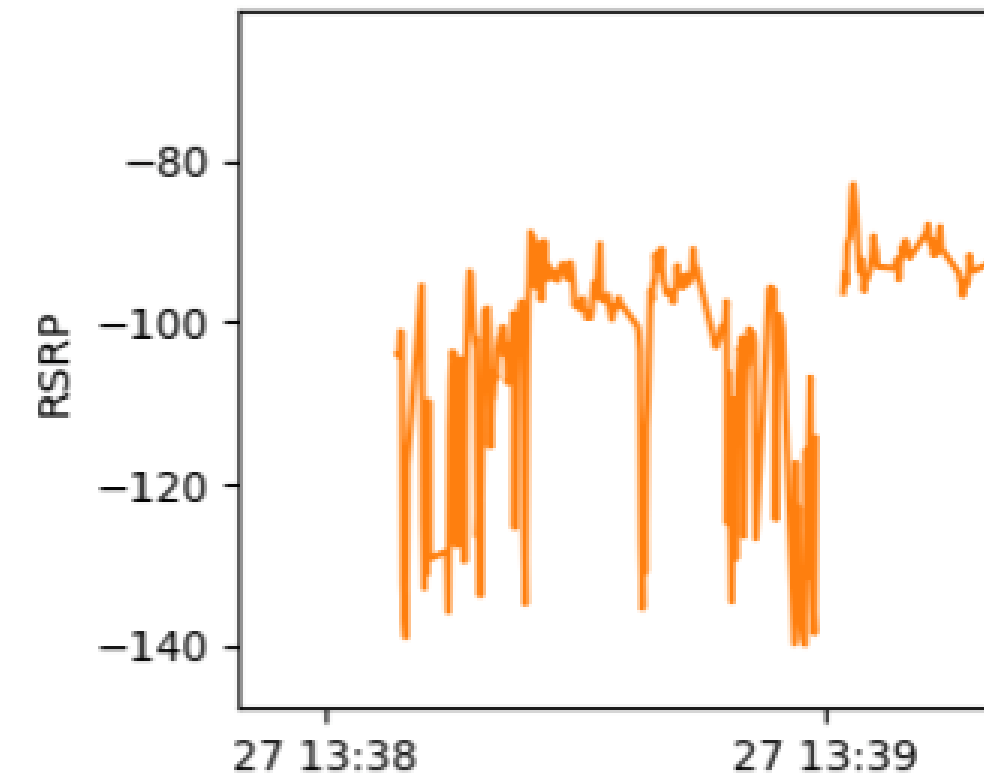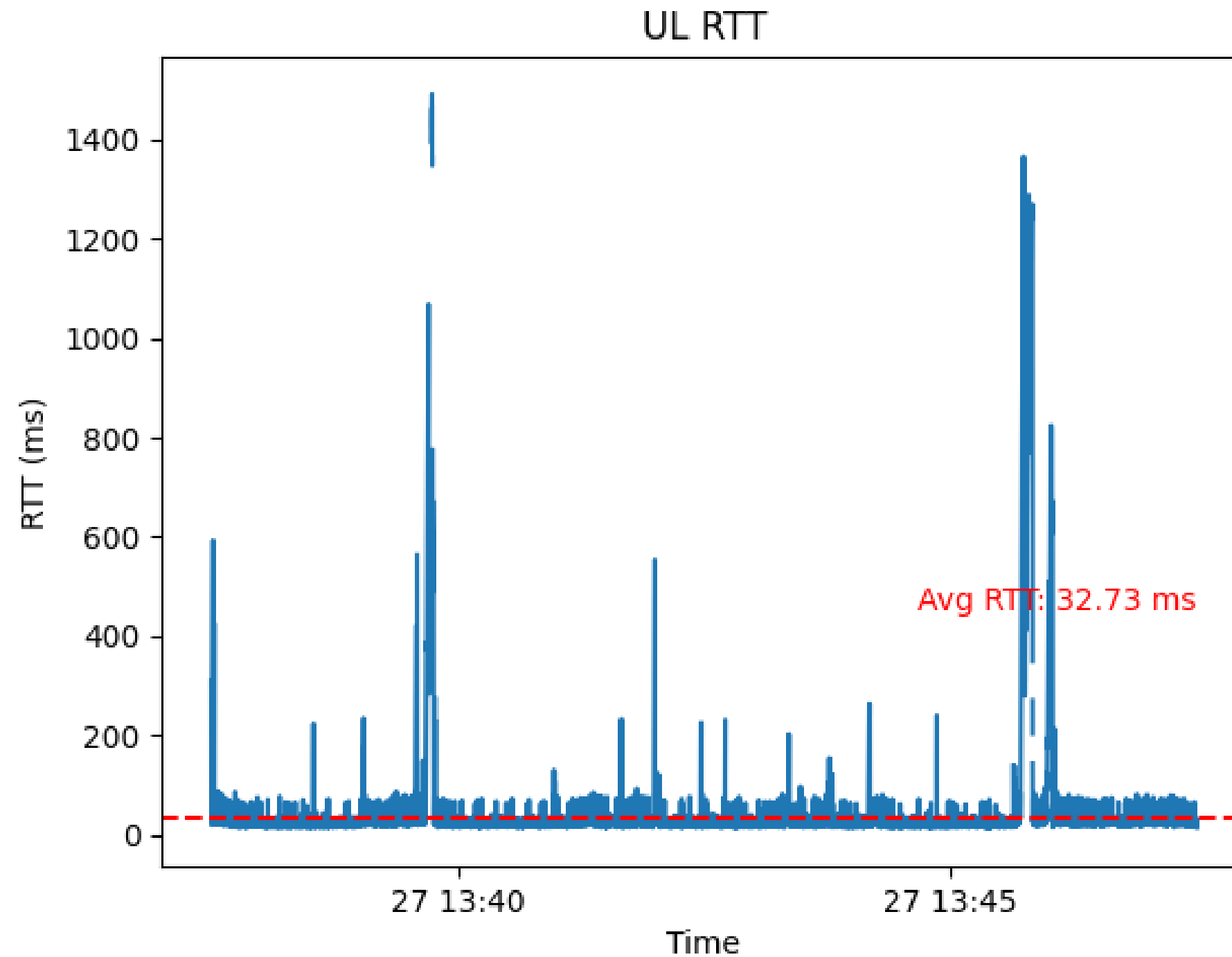
Experiment on the MRT

Condition
- 7 min
- On the MRT
- Green line
- Speed: 35.7 km/h

Discovery
- Only **MN HO** occurs
- 61 to 60, then 60 to 61
- before pci 61, all 1750
- Speed of Cellinfo is weird
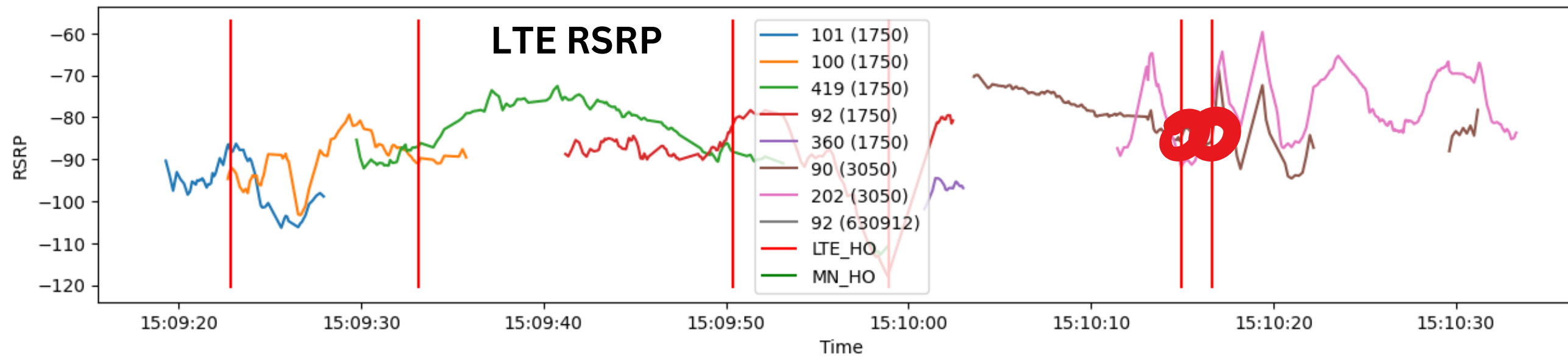- Many pci have both type

Experiment on the MRT

UL RTT

Avg RTT: 32.73 ms

Discovery
- high RTT corresponds to missing signal
  - about 13:39
- Average RTT: 32.73 ms

Experiment on the HSR - Taichung

LTE RSRP

101 (1750)	
100 (1750)	
419 (1750)	
92 (1750)	
360 (1750)	
90 (3050)	
202 (3050)	
92 (630912)	
LTE_HO	
MN_HO	

NR RSRP

101	
100	
419	
92	
360	
90	
202	
SN_setup	

Condition
- 1.5 min
- From 270 to 300 km/h
- Speed recorded by 神盾
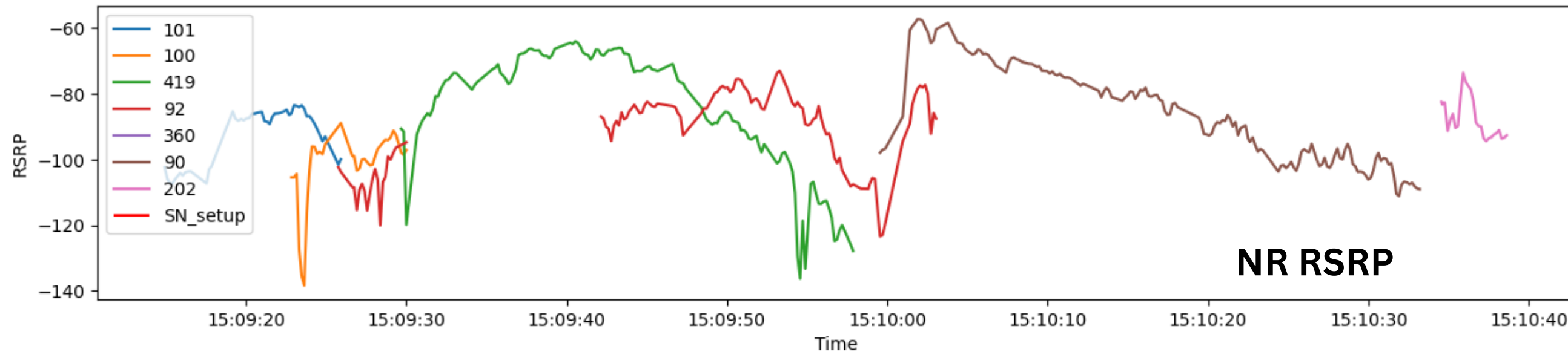
Discovery
- Pci changes so fast
- Only **LTE HO** occurs
- No SN setup
- 90 to 202, then 202 to 90
- Similar signal strength
- Before pci 90, all 1750

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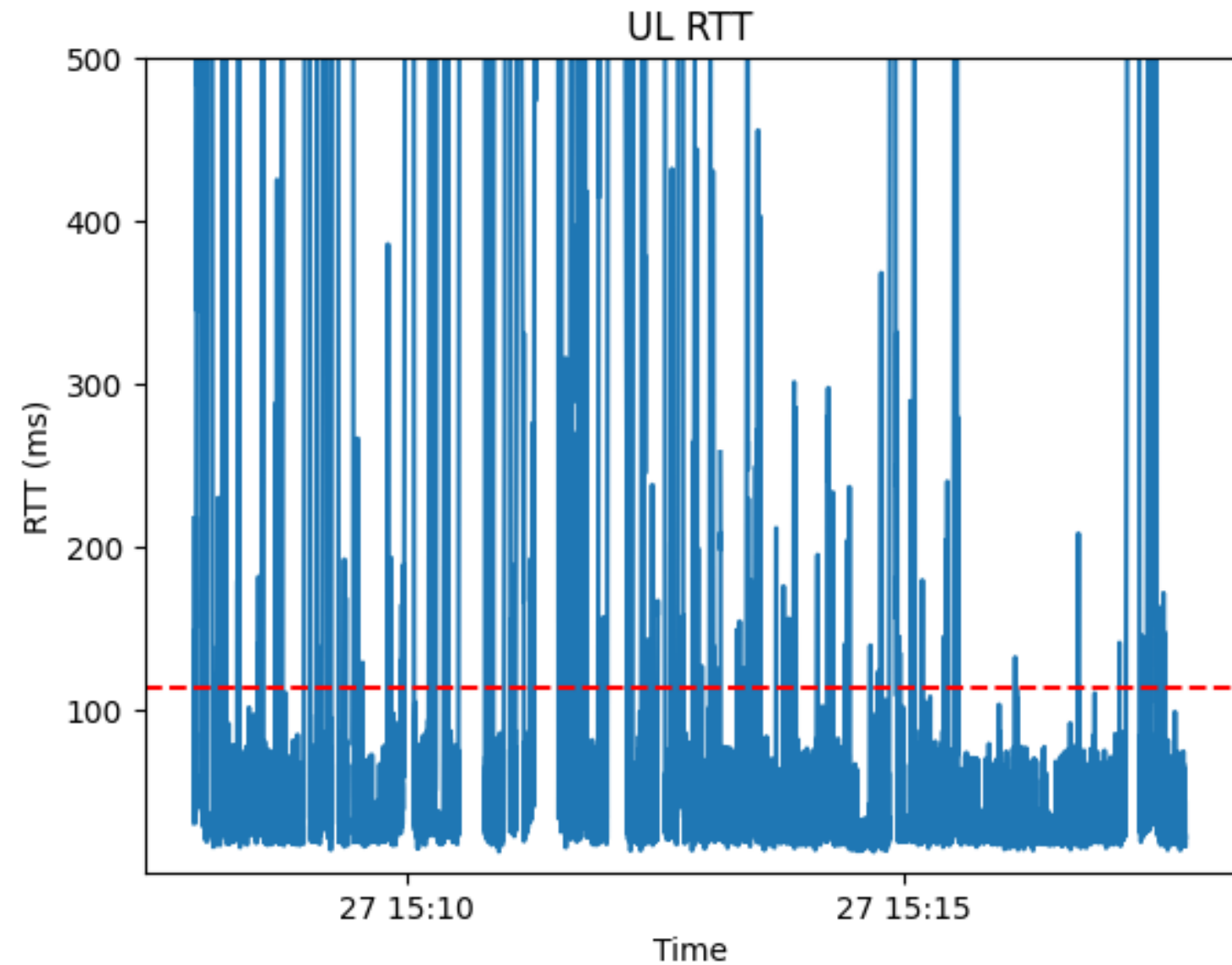# Experiment on the HSR - Taichung
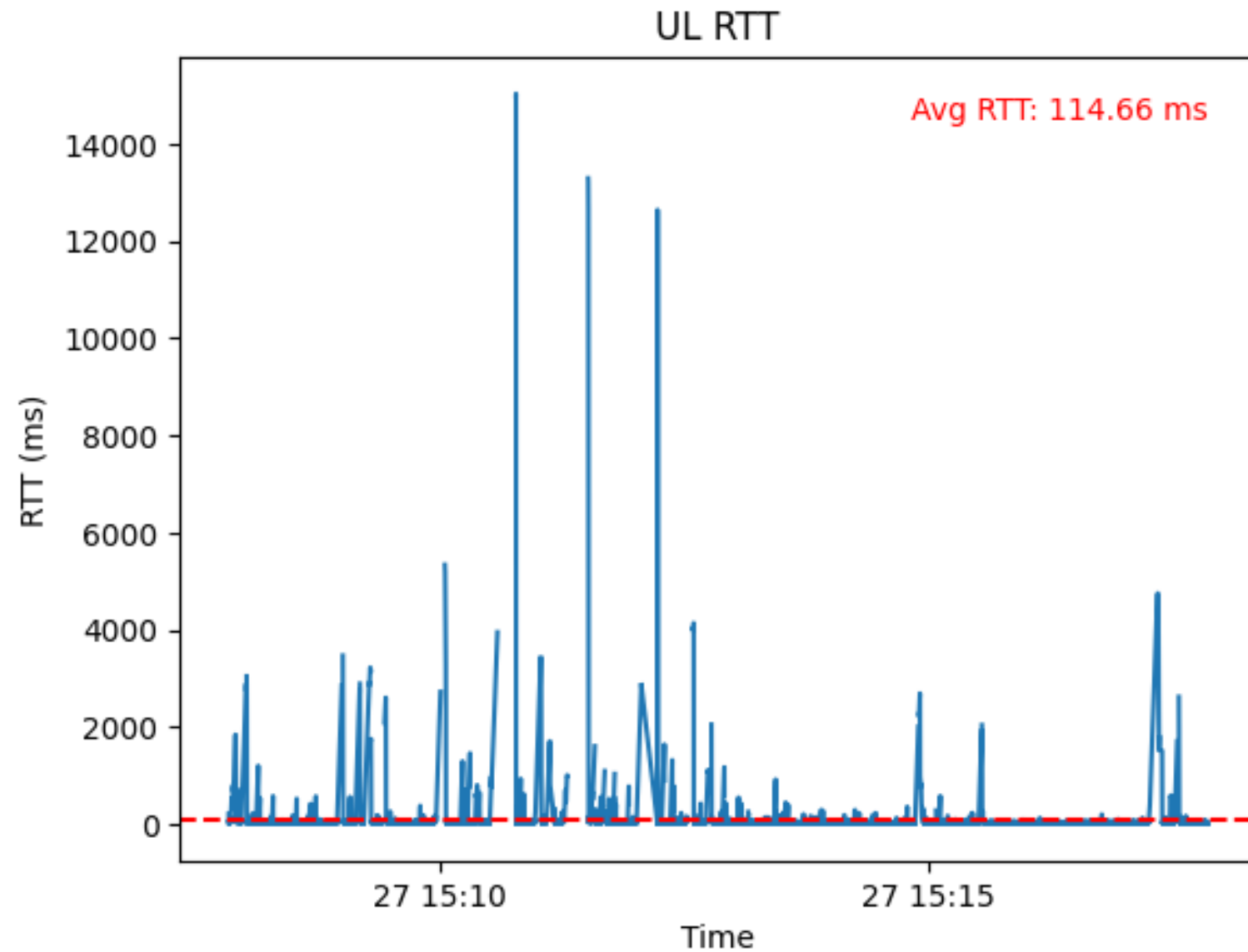
Discovery
- Frizzy RTT
  - speed
- Average RTT: 114.66 ms

Experiment on the HSR - Taoyuan

LTE RSRP
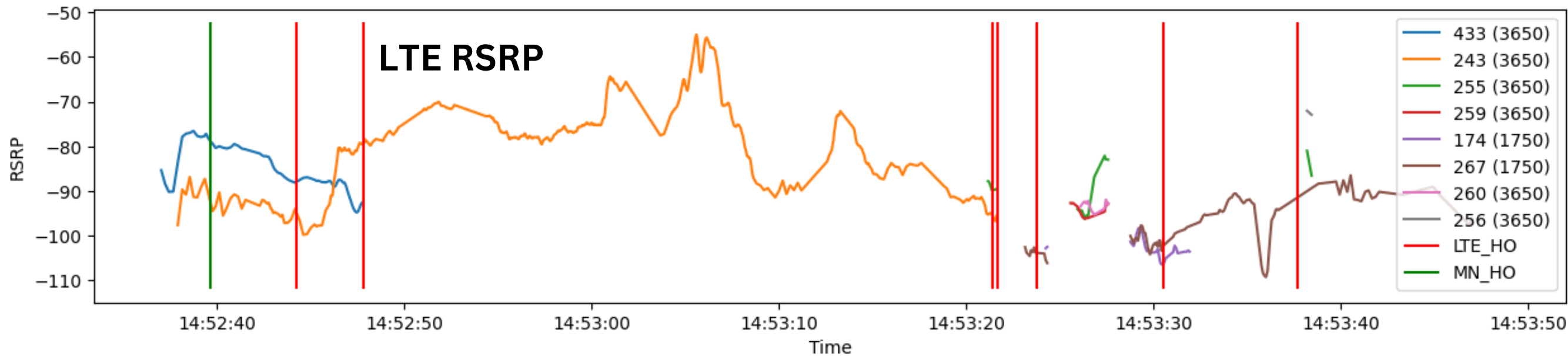
Condition
- 1 min
- About 230 km/h
- A lot of tunnels
- Speed recorded by 神盾

NR RSRP
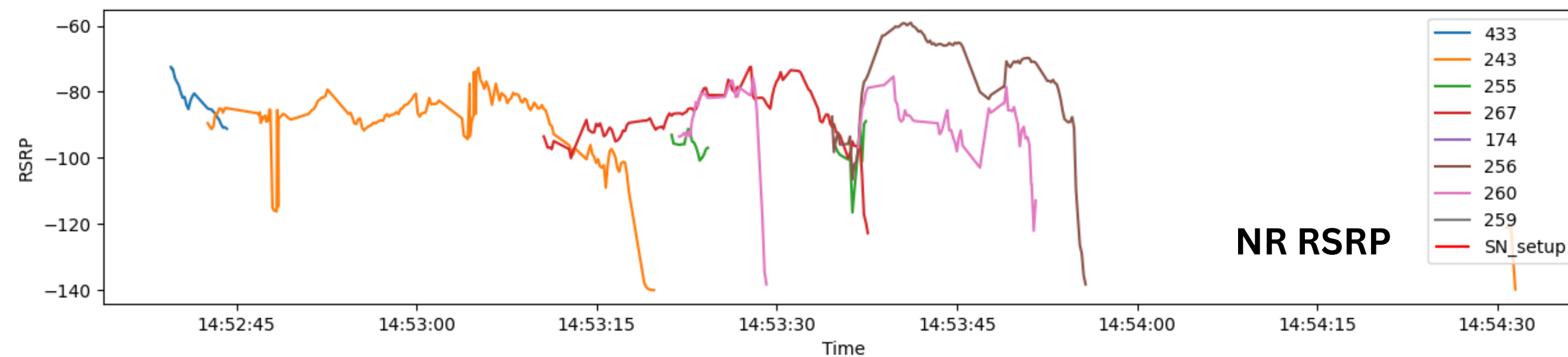
Discovery
- 1 MN but others LTE HO
- Some shattered signals
- 243 occur at the end
- Some odd HO
- No SN Setup

Experiment on the HSR - Taoyuan

LTE RSRP
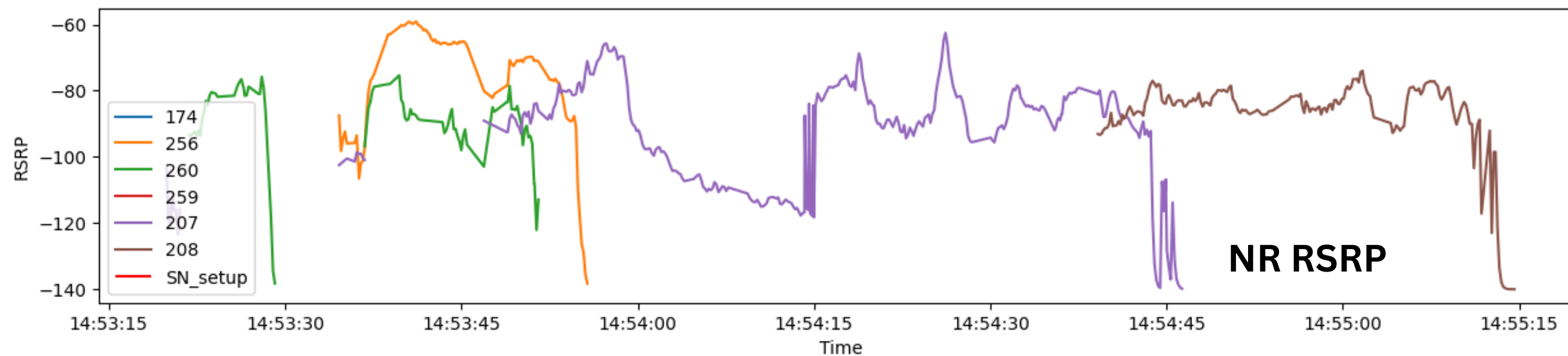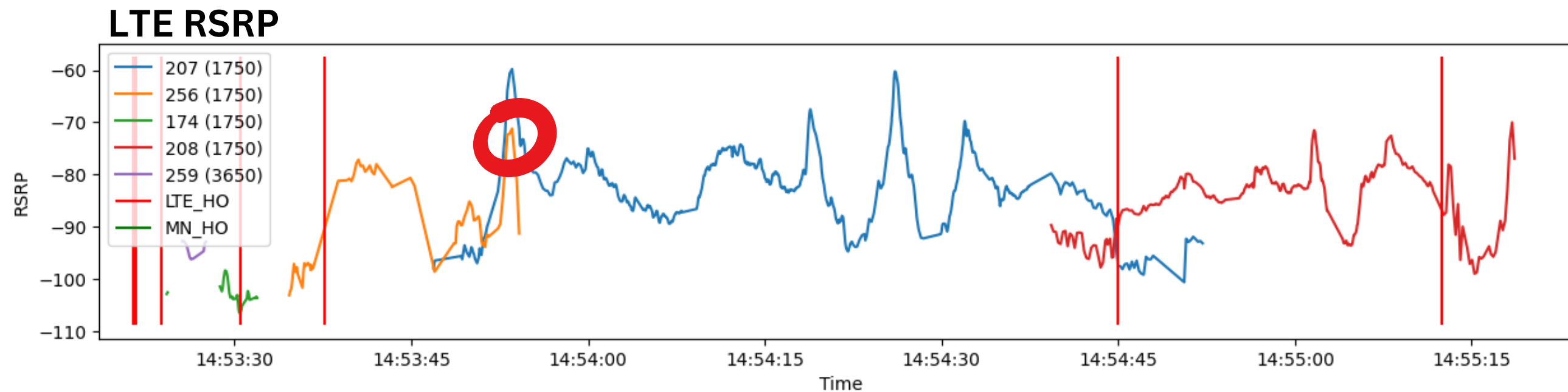
Condition
- 2 min
- From 230 to 270 km/h
- A lot of tunnels
- Speed recorded by 神盾

NR RSRP

Discovery
- Only **LTE HO** occurs
- No SN setup
- No HO to 207
- After pci 259, all 1750
- RSRP decreases dramatically

Experiment on the HSR - Taoyuan
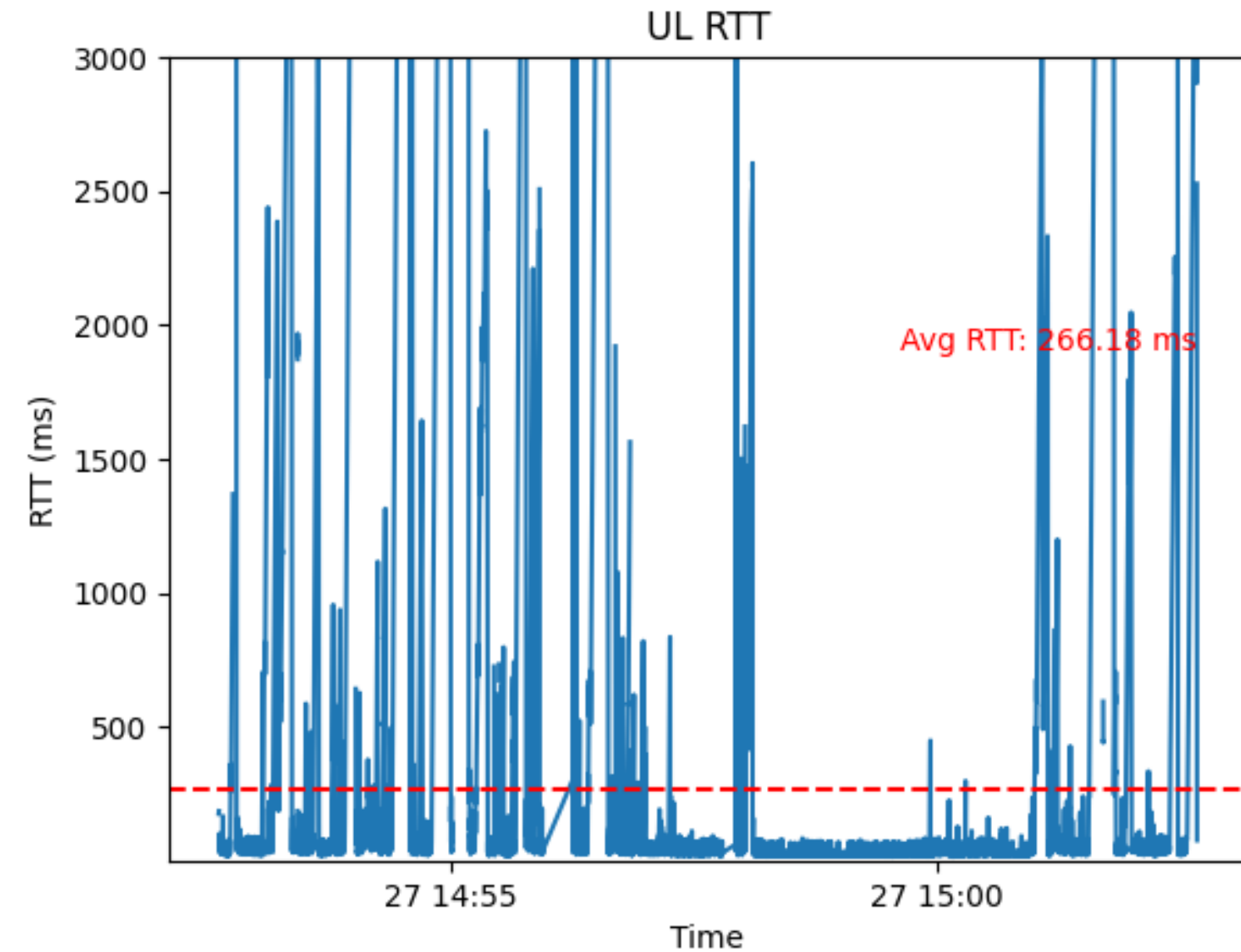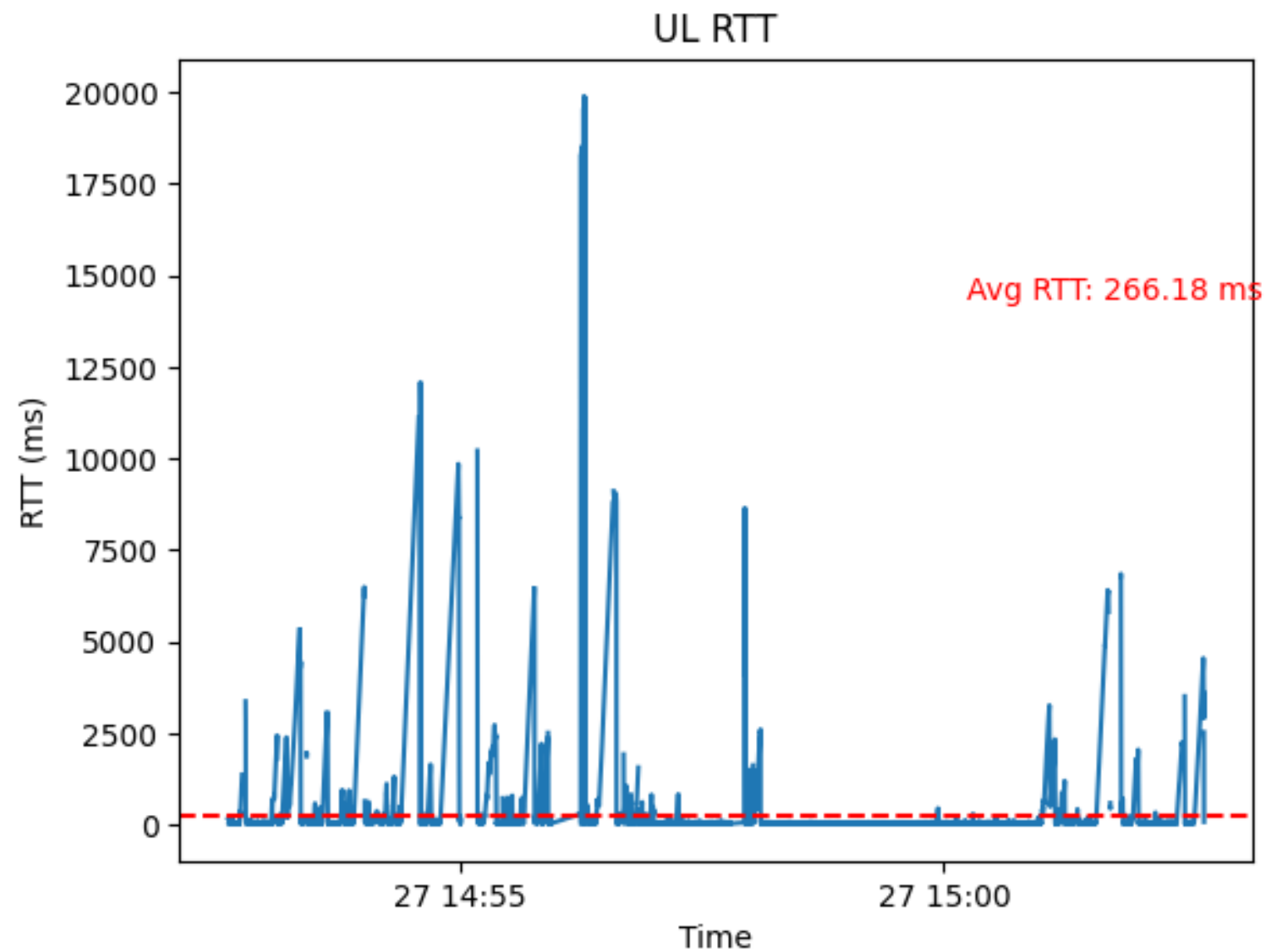
Discovery
- Frizzier RTT than HSR in Taichung
  - speed, tunnels
- Average RTT: 266.18 ms

Experiment on the scooter - Taichung
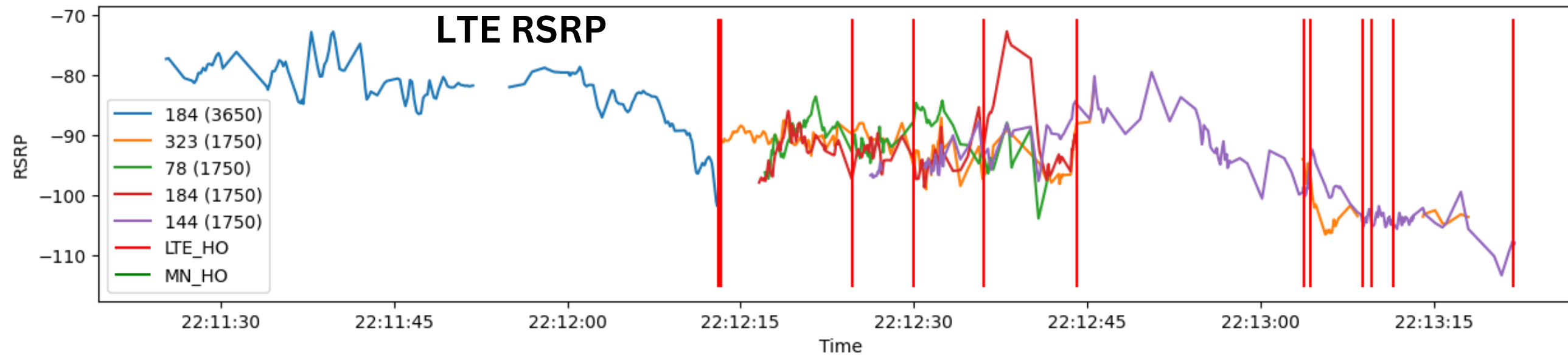
Condition

- 2 min
- In Taichung city
- About 60 km/h
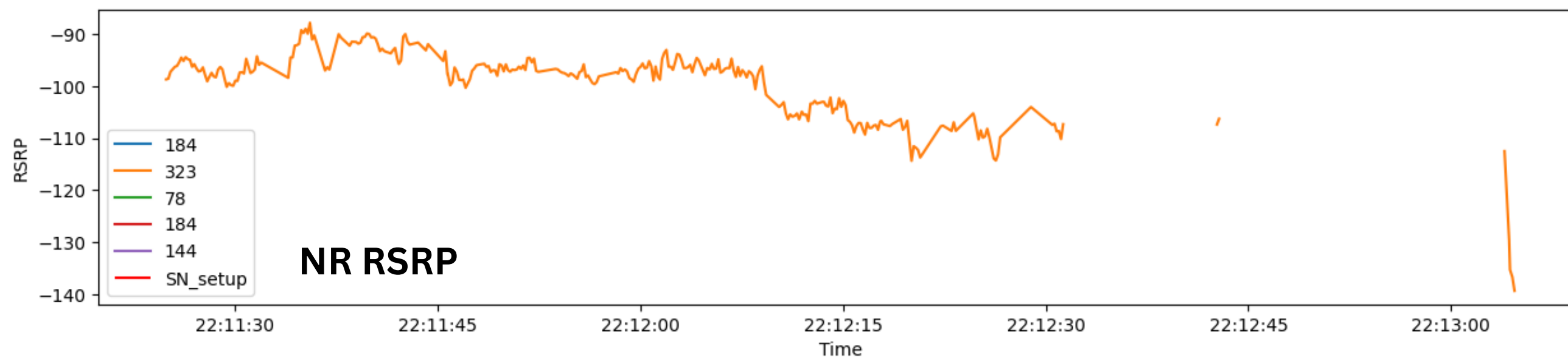
Discovery

- Only LTE HO occurs
- Only 323 has 5G NR signal
- No SN Setup

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Experiment on the scooter - Taichung

Discovery
- Stable and small RTT
  - speed, in the city
- Average RTT: 31.72 ms
- A lot of HO results in extremely high RTT

OBSERVATIONS

LTE dominate on the HSR

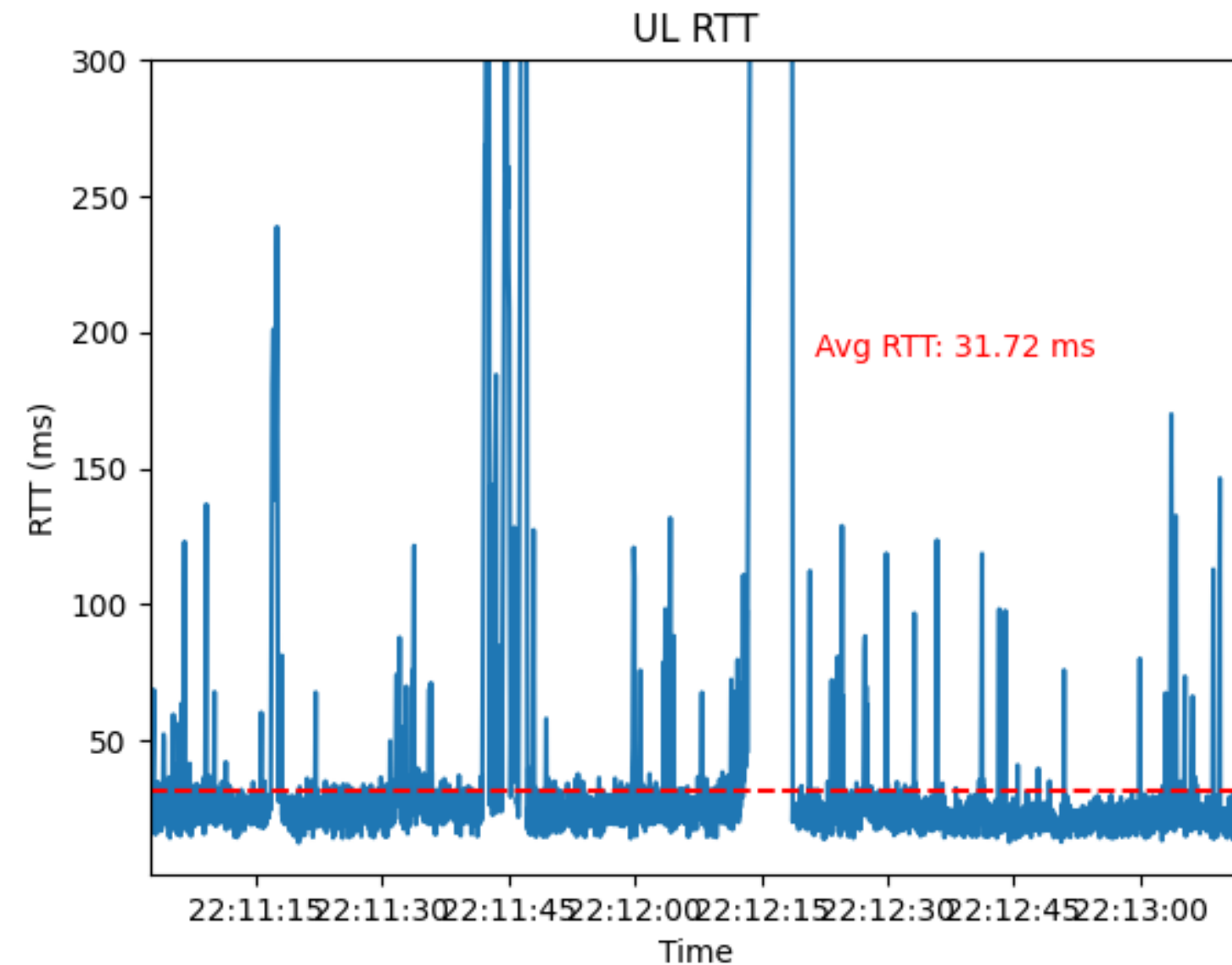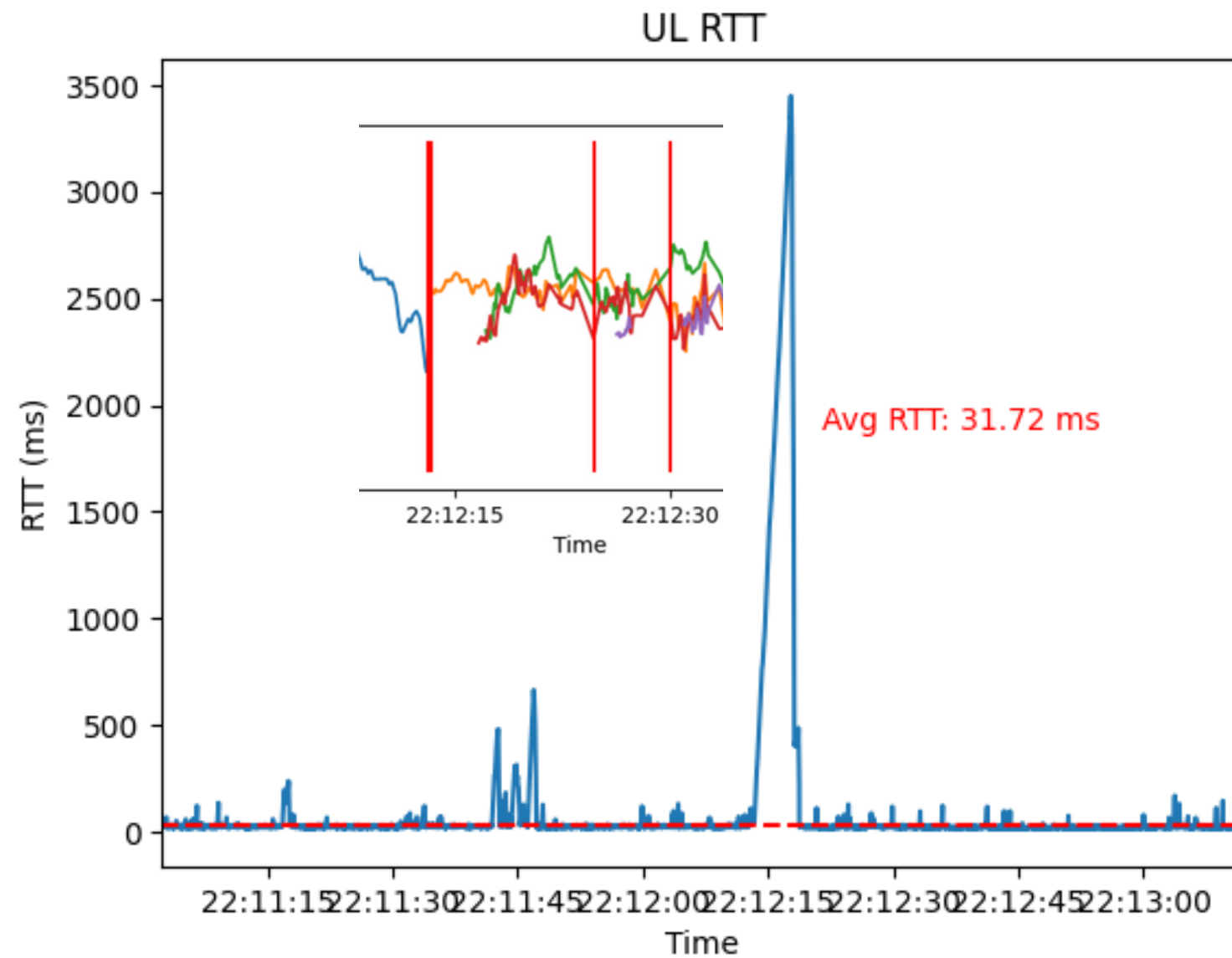|				
2023-04-27 06:53:27.427625	LTE_RRC_OTA_Packet	255	UL	3650
2023-04-27 06:53:27.427863	LTE_RRC_OTA_Packet	255	UL	3650
2023-04-27 06:53:27.456322	LTE_RRC_OTA_Packet	255	DL	3650
2023-04-27 06:53:27.456922	LTE_RRC_OTA_Packet	255	UL	3650
2023-04-27 06:53:27.575797	LTE_RRC_OTA_Packet	255	UL	3650
2023-04-27 06:53:27.597128	5G_NR_RRC_OTA_Packet	0	-	0
2023-04-27 06:53:27.598170	LTE_RRC_OTA_Packet	255	DL	3650
2023-04-27 06:53:27.620201	LTE_RRC_OTA_Packet	255	UL	1750
2023-04-27 06:53:27.651580	LTE_RRC_OTA_Packet	255	DL	1750
2023-04-27 06:53:27.656319	LTE_RRC_OTA_Packet	255	-	1750
2023-04-27 06:53:27.656406	LTE_RRC_OTA_Packet	255	-	1750
2023-04-27 06:53:27.656407	LTE_RRC_OTA_Packet	255	-	1750
2023-04-27 06:53:27.656409	LTE_RRC_OTA_Packet	255	-	1750
2023-04-27 06:53:27.656409	LTE_RRC_OTA_Packet	255	-	1750
2023-04-27 06:53:27.656482	LTE_RRC_Serv_Cell_Info	255		
2023-04-27 06:53:27.674043	LTE_RRC_OTA_Packet	255	UL	1750
2023-04-27 06:53:27.674195	LTE_RRC_OTA_Packet	255	UL	1750
2023-04-27 06:53:27.775169	LTE_RRC_OTA_Packet	255	UL	1750
2023-04-27 06:53:27.803750	LTE_RRC_OTA_Packet	255	DL	1750

2023-04-27 07:10:03.214147	LTE_RRC_OTA_Packet	90	-	3050
2023-04-27 07:10:03.250207	LTE_RRC_OTA_Packet	90	-	3050
2023-04-27 07:10:03.257620	LTE_RRC_OTA_Packet	90	-	3050
2023-04-27 07:10:03.257650	LTE_RRC_Serv_Cell_Info	90		
2023-04-27 07:10:03.269129	LTE_RRC_OTA_Packet	90	-	3050
2023-04-27 07:10:00.074162	LTE_RRC_OTA_Packet	360	-	1750
2023-04-27 07:10:00.090198	LTE_RRC_OTA_Packet	360	-	1750
2023-04-27 07:10:00.110161	LTE_RRC_OTA_Packet	360	-	1750
2023-04-27 07:10:00.210234	LTE_RRC_OTA_Packet	360	-	1750
2023-04-27 07:10:00.235609	LTE_RRC_OTA_Packet	360	-	1750
2023-04-27 07:10:00.235639	LTE_RRC_Serv_Cell_Info	360		
2023-04-27 07:10:00.390305	LTE_RRC_OTA_Packet	360	-	1750
2023-04-27 07:10:00.618146	LTE_RRC_OTA_Packet	360	-	1750
2023-04-27 07:10:00.711384	LTE_RRC_Serv_Cell_Info	360		
2023-04-27 07:10:00.731445	LTE_RRC_OTA_Packet	360	-	1750
2023-04-27 07:10:00.856450	LTE_RRC_OTA_Packet	360	-	1750

- I find that **LTE** almost dominate the transmission on the HSR
- There is a **pci 0** with **0 frequency** occur
  - signaling of communication with the NR BS
  - not yet turning into nr serving cell
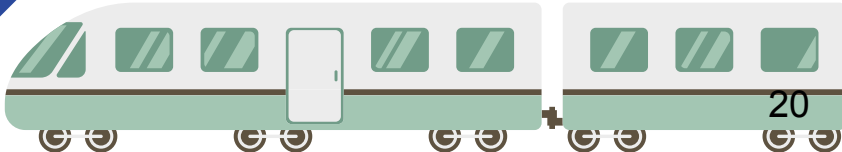
5G NR Uses High frequency

2023-04-27 07:10:22.591982	5G_NR_RRC_OTA_Packet	146	-	630912
2023-04-27 07:10:22.592004	5G_NR_RRC_OTA_Packet	146	-	630912
2023-04-27 07:10:22.605091	5G_NR_RRC_OTA_Packet	90	UL	630912
2023-04-27 07:10:22.605192	LTE_RRC_OTA_Packet	202	UL	3050
2023-04-27 07:10:23.000012	LTE_RRC_OTA_Packet	202	DL	3050
2023-04-27 07:10:23.000331	5G_NR_RRC_OTA_Packet	90	-	630912
2023-04-27 07:10:23.009434	5G_NR_RRC_OTA_Packet	90	UL	630912

2023-04-27 06:53:04.898790	5G_NR_RRC_OTA_Packet	243	UL	432290
2023-04-27 06:53:04.898903	LTE_RRC_OTA_Packet	243	UL	3650
2023-04-27 06:53:04.936342	LTE_RRC_OTA_Packet	243	DL	3650
2023-04-27 06:53:04.937136	5G_NR_RRC_OTA_Packet	243	-	432290
2023-04-27 06:53:04.937148	5G_NR_RRC_OTA_Packet	243	-	432290
2023-04-27 06:53:04.953295	5G_NR_RRC_OTA_Packet	243	UL	630912

2023-04-27 06:53:22.031952	LTE_RRC_OTA_Packet	255	-	1750
2023-04-27 06:53:22.660081	LTE_RRC_OTA_Packet	255	-	1750
2023-04-27 06:53:23.660785	LTE_RRC_OTA_Packet	255	UL	1750
2023-04-27 06:53:23.743814	5G_NR_RRC_OTA_Packet	267	-	630912
2023-04-27 06:53:23.743834	5G_NR_RRC_OTA_Packet	267	-	630912
2023-04-27 06:53:23.746560	LTE_RRC_OTA_Packet	255	DL	1750
2023-04-27 06:53:23.761920	5G_NR_RRC_OTA_Packet	267	UL	630912
2023-04-27 06:53:23.762076	LTE_RRC_OTA_Packet	267	UL	1750
2023-04-27 06:53:24.036987	LTE_RRC_OTA_Packet	267	DL	1750
2023-04-27 06:53:24.038056	LTE_RRC_OTA_Packet	267	UL	1750
2023-04-27 06:53:24.164128	LTE_RRC_OTA_Packet	267	DL	1750
2023-04-27 06:53:24.325761	LTE_RRC_OTA_Packet	267	UL	1750
2023-04-27 06:53:24.563960	LTE_RRC_OTA_Packet	10	-	3650
2023-04-27 06:53:25.300759	LTE_RRC_OTA_Packet	174	-	3650
2023-04-27 06:53:25.436386	LTE_RRC_OTA_Packet	259	-	3650
2023-04-27 06:53:25.503171	LTE_RRC_OTA_Packet	259	-	3650

- I find that 5G NR really uses **higher frequency** in the transmission
- Many frequencies being **reused** and occur a lot (ex: 1750, 3650 and 630912)

The Strength of 5G NR Signal
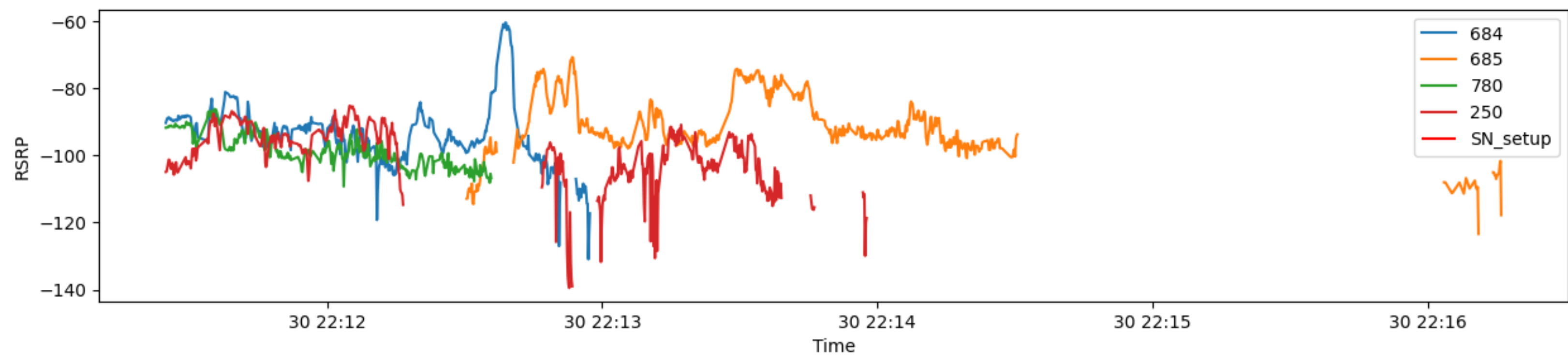
|			
5G_NR_RRC_OTA_Packet	780	-	630912
5G_NR_RRC_OTA_Packet	684	UL	630912
LTE_RRC_OTA_Packet	323	UL	1750
LTE_RRC_OTA_Packet	323	-	1750
LTE_RRC_OTA_Packet	323	-	1750
LTE_RRC_OTA_Packet	323	-	1750
LTE_RRC_OTA_Packet	323	-	1750
LTE_RRC_OTA_Packet	323	UL	1750
LTE_RRC_OTA_Packet	78	DL	1750

Condition
- Measured in Taichung City
- On the scooter

Discovery
- Since it's measured in the city with slow velocity
  - The signal of different pci overlap a lot
  - 5G NR signal seems more stable than on the HSR

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Same pci with different frequencies
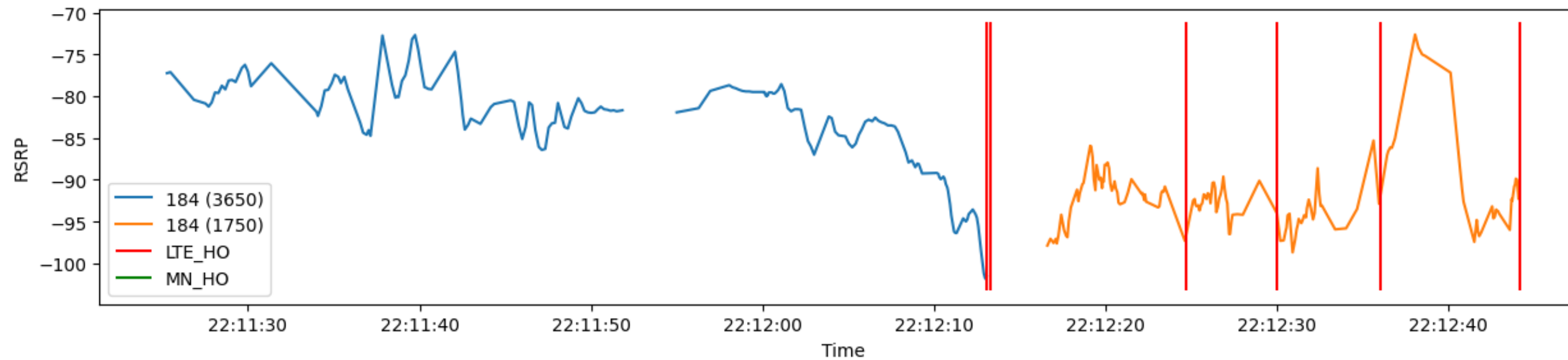
Condition
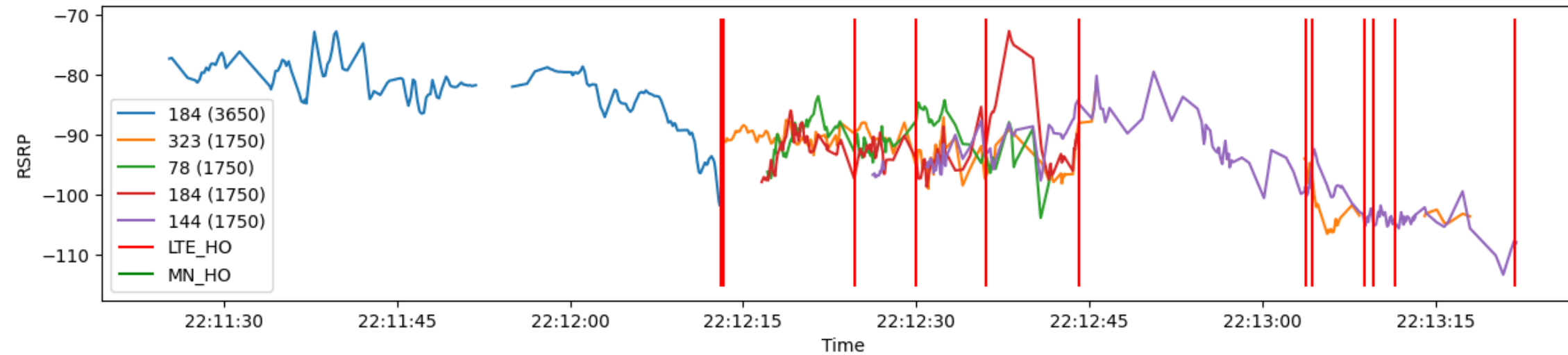
- Measured in Taichung City
- On the scooter

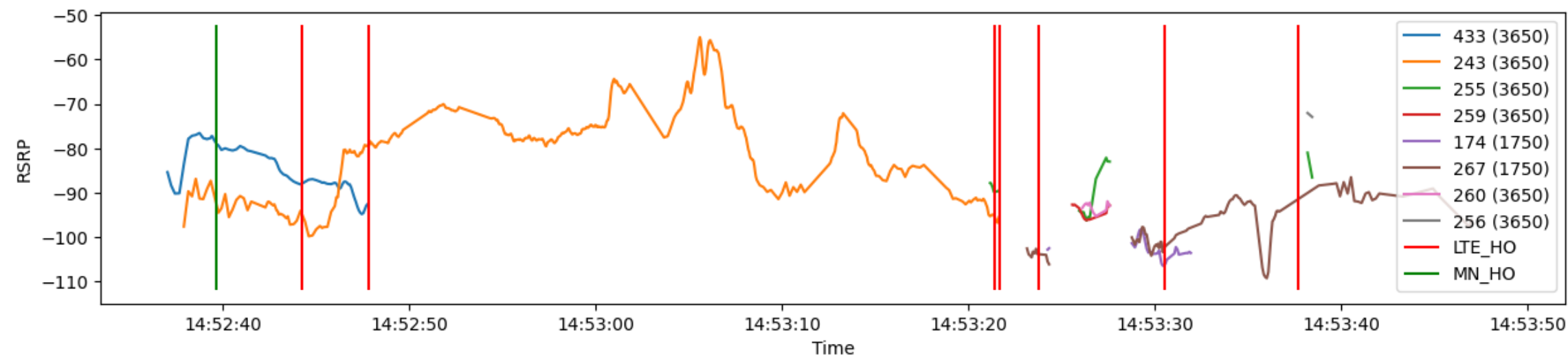| 184	DL	3650
184	UL	3650

Discovery

- Pci 184 uses frequency 3650 and then use 1750
- It is not because of the UL or DL
- Since 1 pci can has a lot of frequencies
  - The performance of the 3650 is just better at first
  - Since the movement ⟶ Direction ?
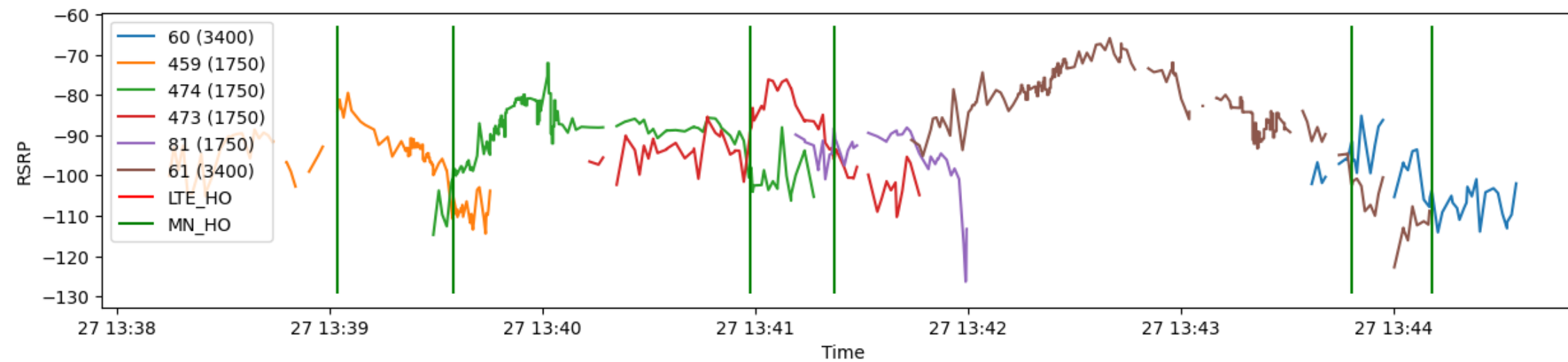
Many frequencies being reused
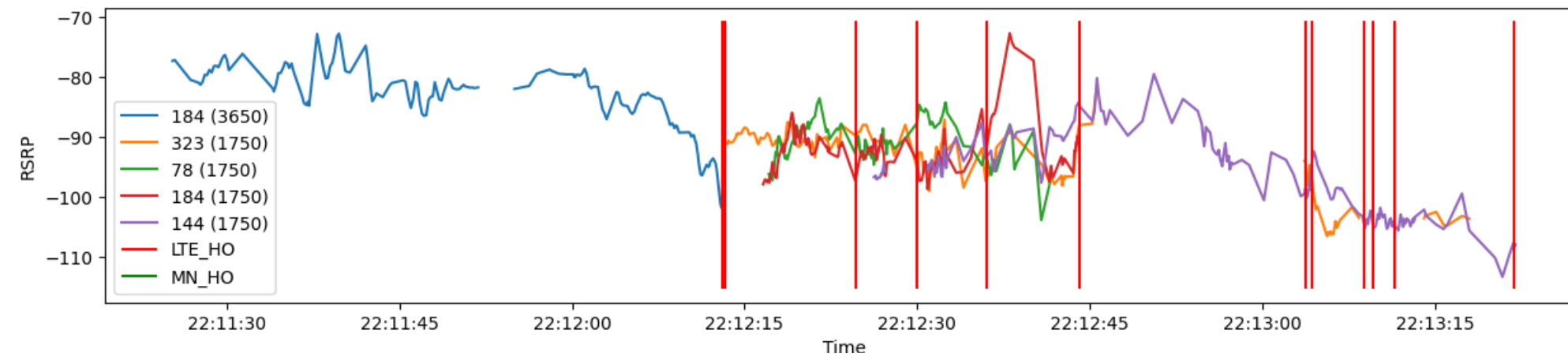

Taichung

Taoyuan

Taipei

Discovery
- 1750 and 3650 are reused
- 630912 is reused as well

- Maybe the performance of these frequencies are better
- Maybe they only buy these frequencies

Search
- 1750 used in FDD
- 3650 used in TDD

Comparison of Taichung and Taipei

Condition
- Taichung
- Scooter (60 km/hr)

Comparison
- Taichung has only **LTE HO**
- Not much pci has both signal type
- About **6 HO/min**
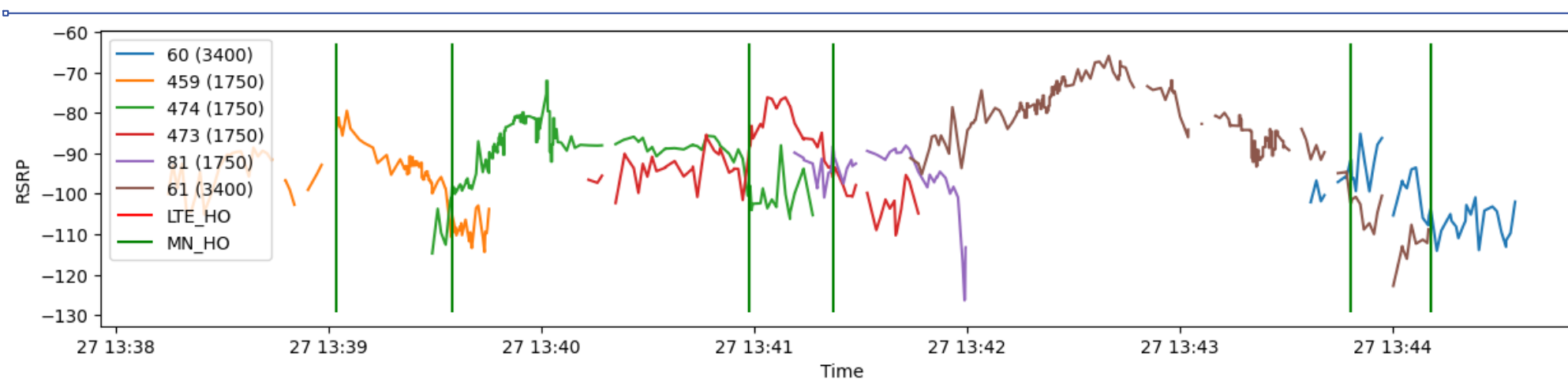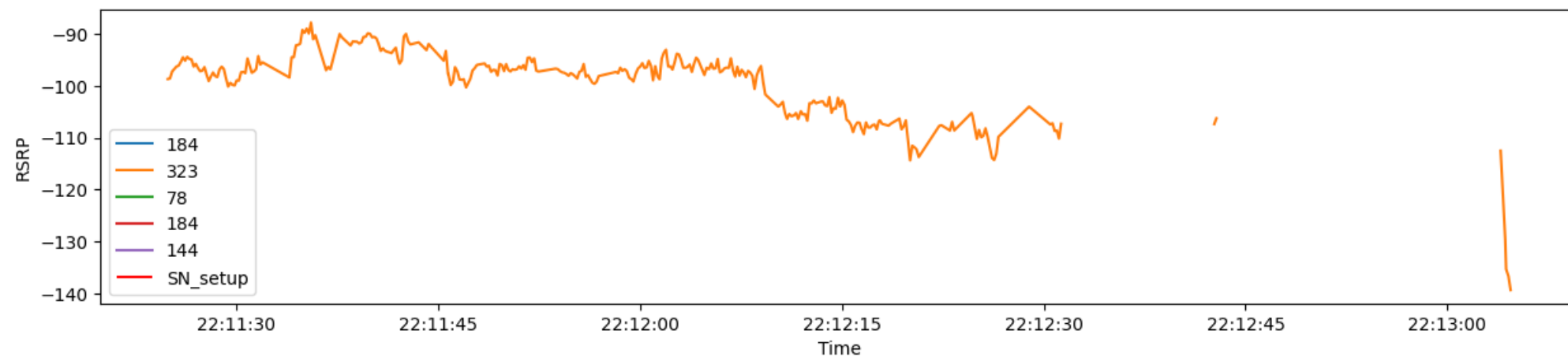
Condition
- Taipei
- MRT (35.7 km/hr)

Comparison
- Pci in Taipei usually have **both** signal type
- Taipei has all **MN HO**
- About **1 HO/min**

RTT Comparison of MRT and HSR

UL RTT — MRT — Avg RTT: 32.73 ms

UL RTT — HSR — Avg RTT: 114.66 ms
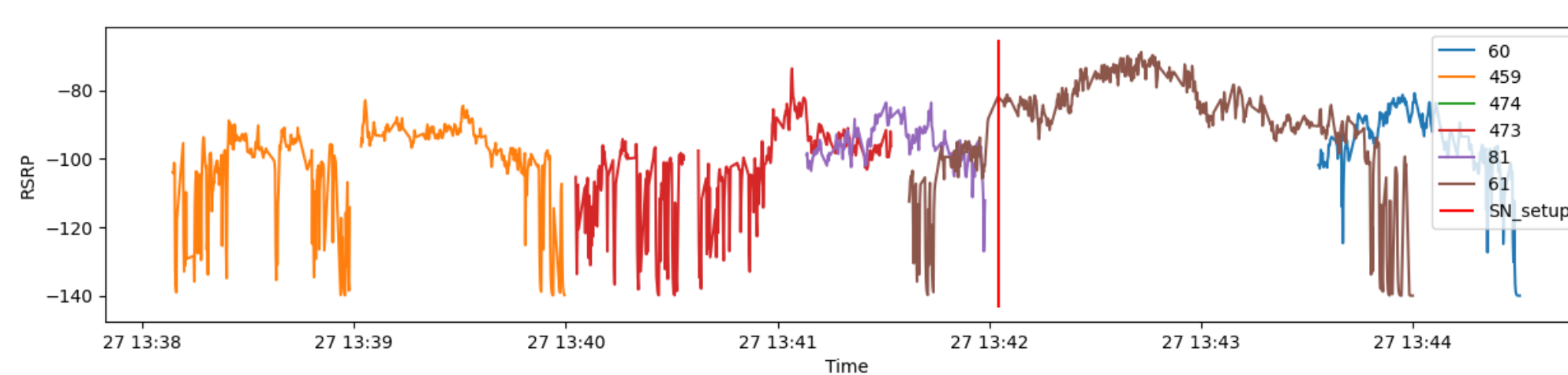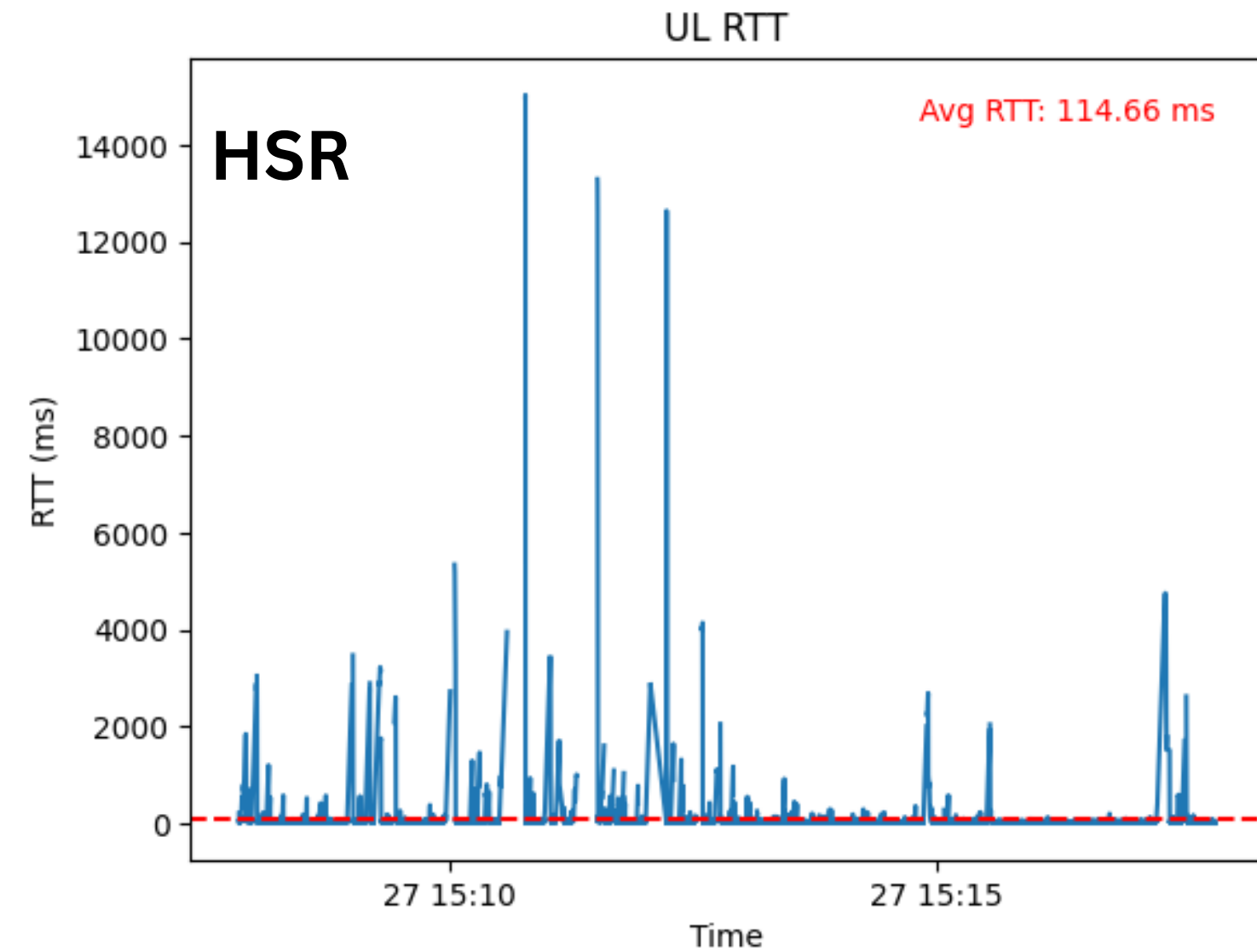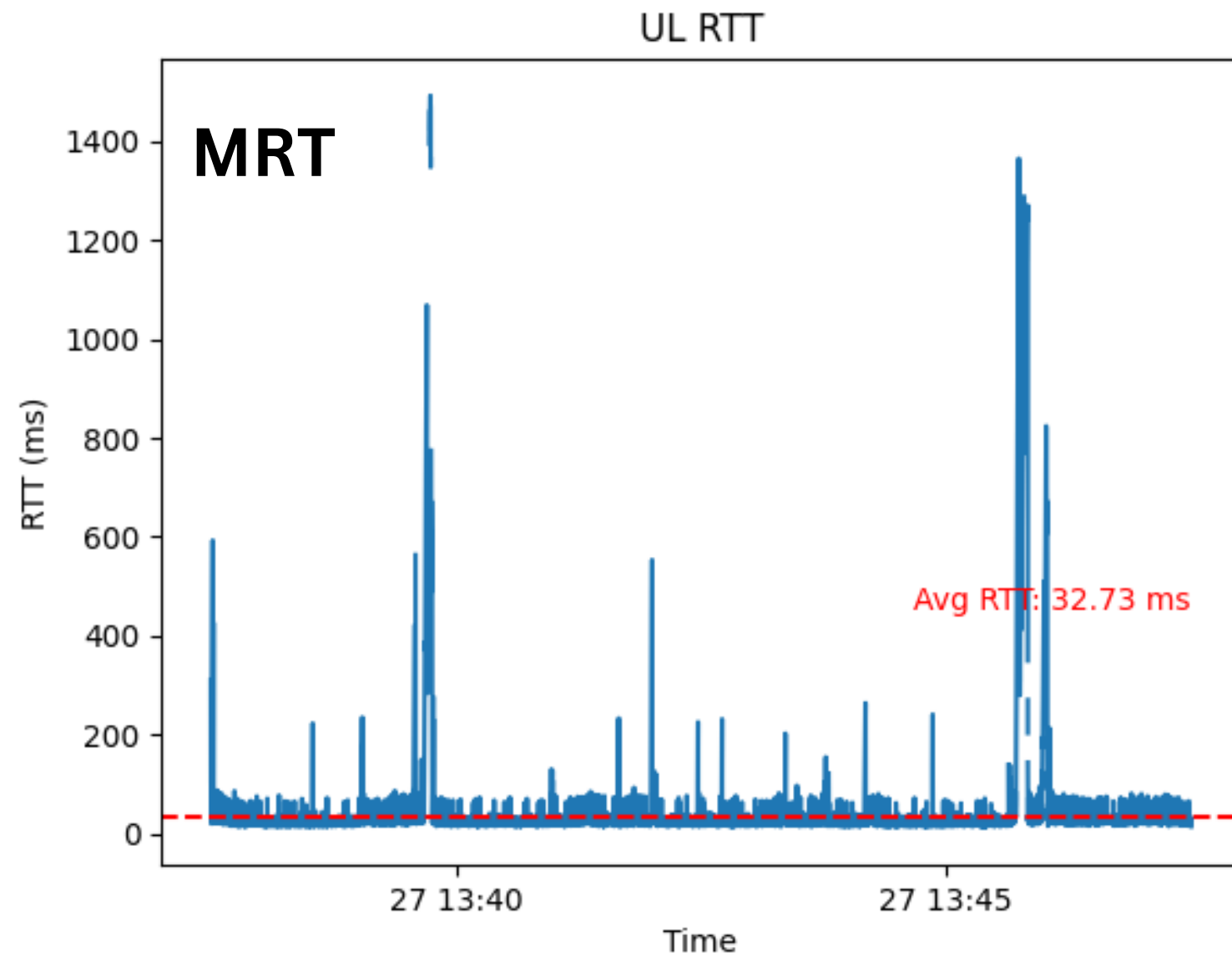
Comparison
- MRT has much lower RTT
  - Speed (40 km/h vs 300 km/hr)

RTT Comparison of MRT and Scooter
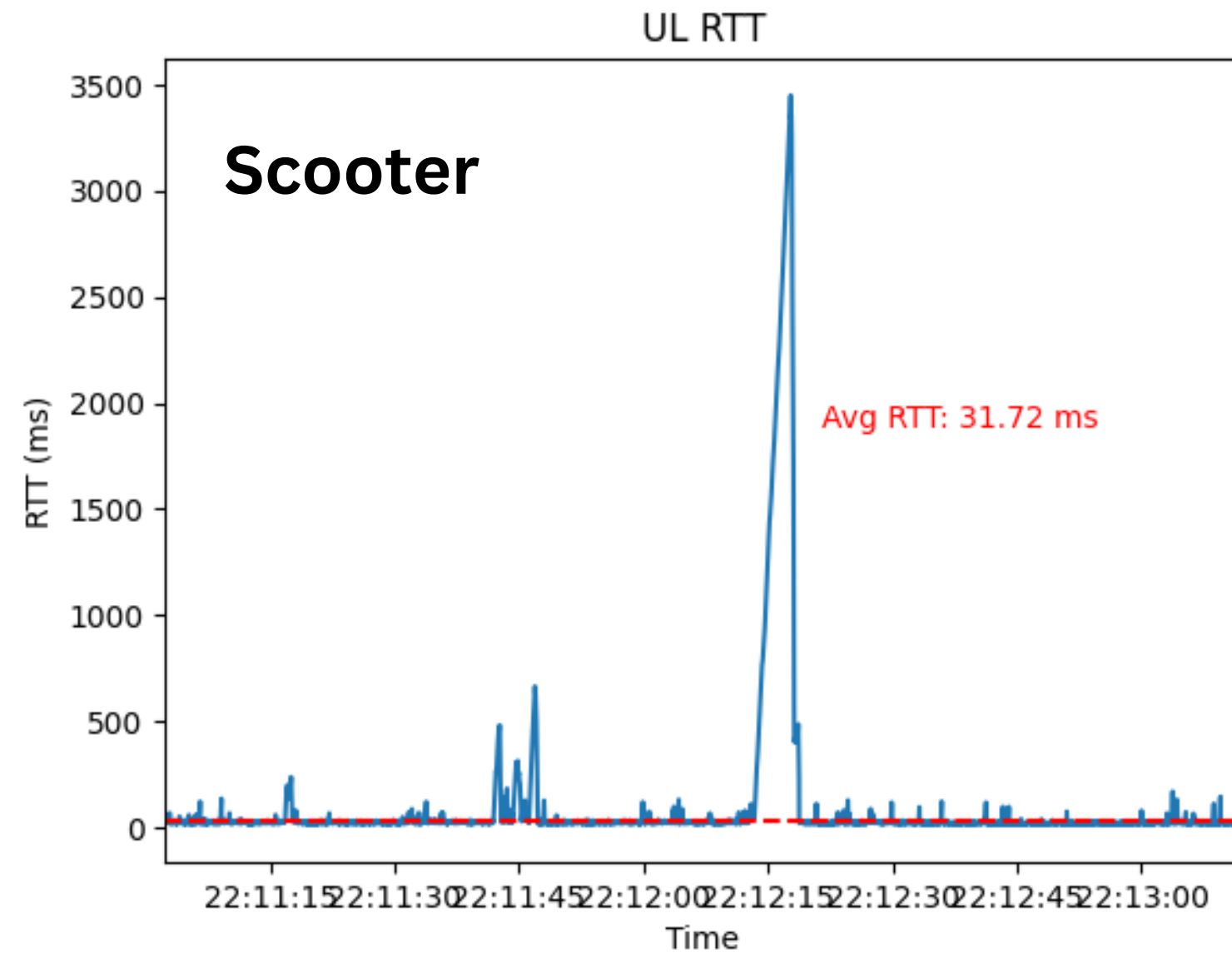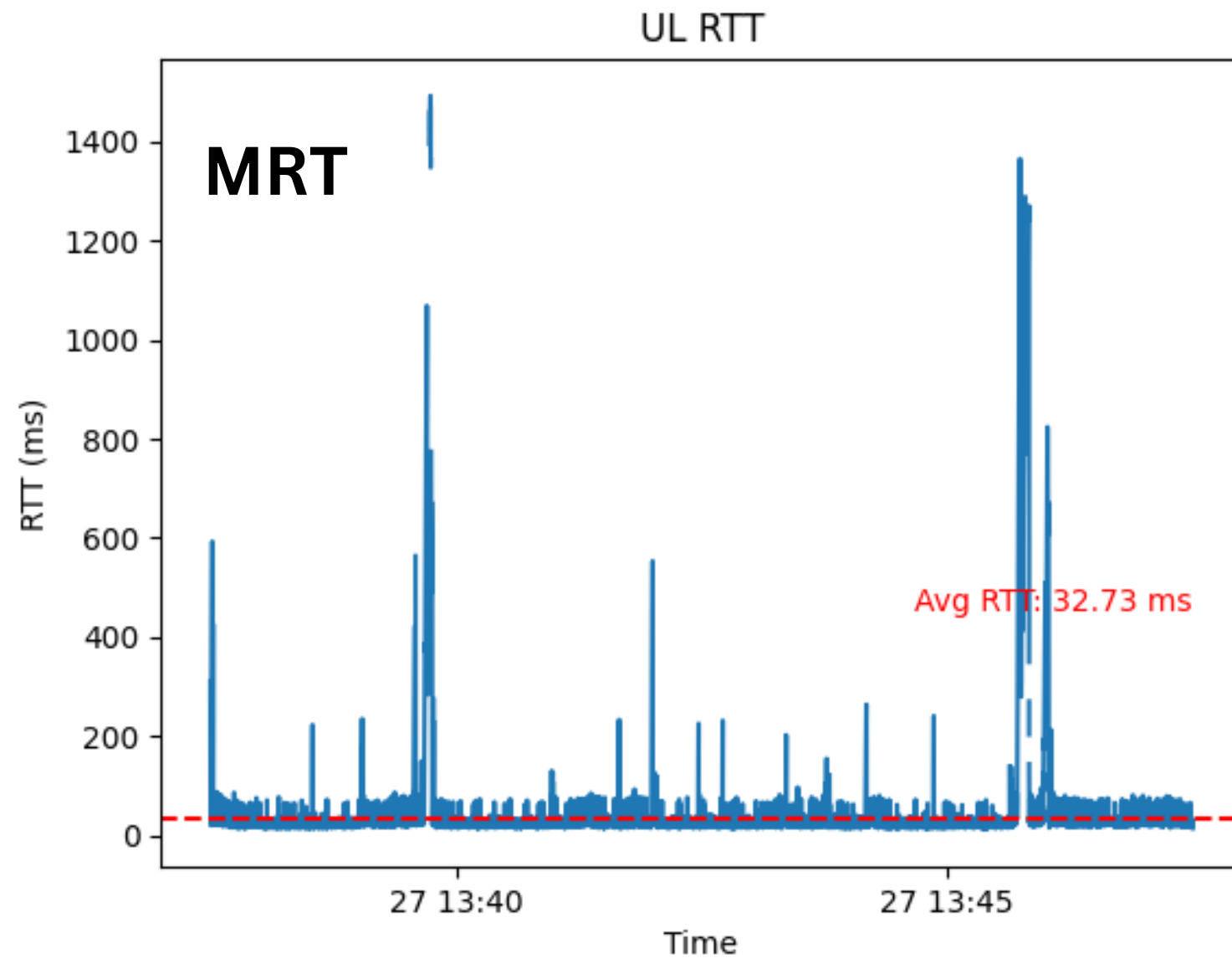
Comparison

- Average RTT is similar
  - Speed is similar (40 km/h vs 60 km/h)

- Maximum RTT of scooter is larger
  - speed is a little bit larger (60 km/hr)

RTT Comparison on the HSR

Taichung — UL RTT, Avg RTT: 114.66 ms

Taoyuan — UL RTT, Avg RTT: 266.18 ms
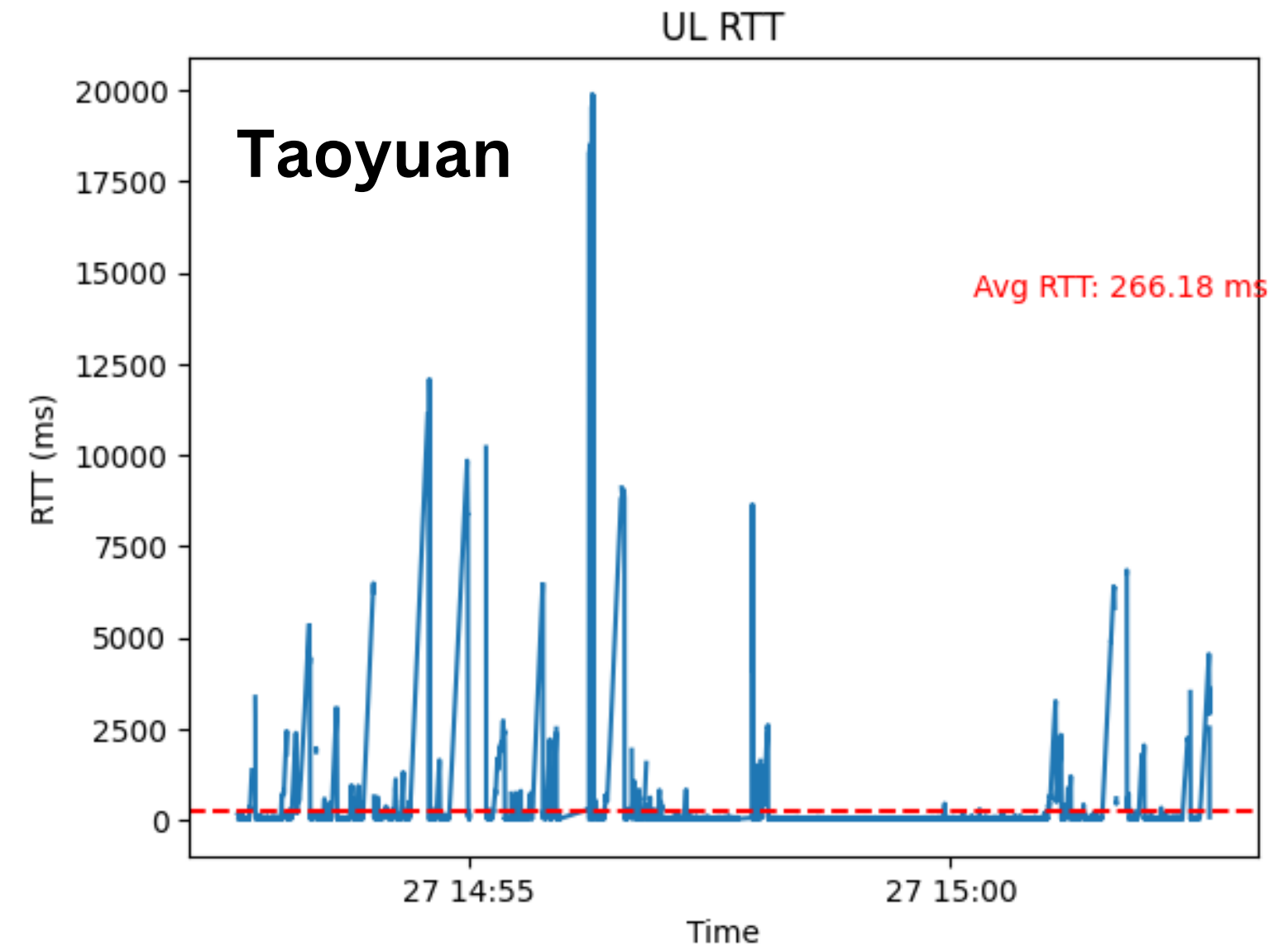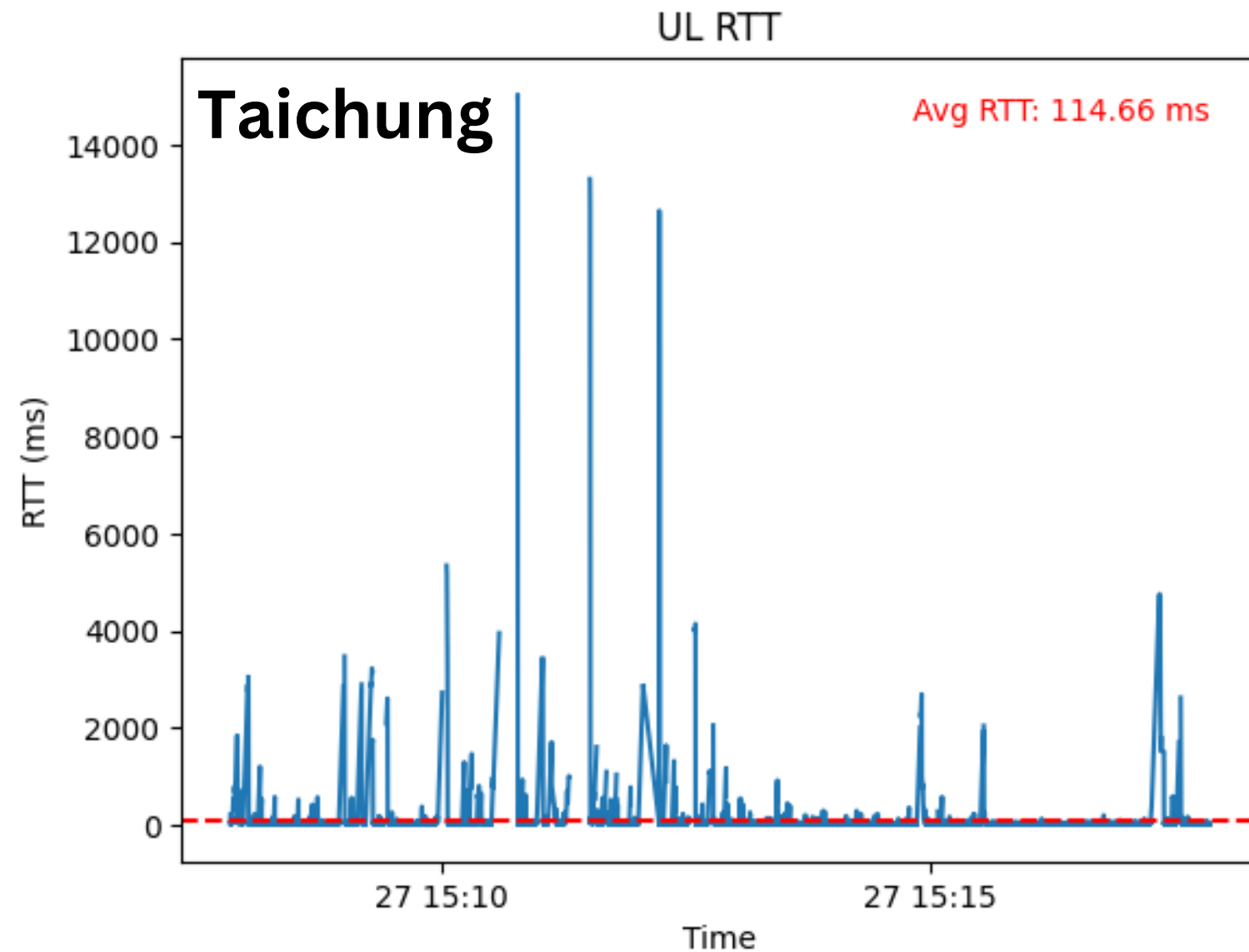
Comparison
- RTT of Taoyuan is larger than in Taichung
  - Tunnels result in the bad signaling

DIFFICULTIES

Bugs during the experiment 🐛

```
(base) zoungming@Mgtmc [14時52分26秒] [~] [main *]
[-> % adb devices
* daemon not running; starting now at tcp:5037
* daemon started successfully
List of devices attached
e8c1eff5        unauthorized

(base) zoungming@Mgtmc [14時52分36秒] [~] [main *]
[-> % adb shell
adb: device unauthorized.
This adb server's $ADB_VENDOR_KEYS is not set
Try 'adb kill-server' if that seems wrong.
Otherwise check for a confirmation dialog on your device.
```

Condition:
- Trying to adb shell in the phone
- The phone's battery died before

Solution:
- Check the **usb debug**
  - usb debug is in the **developer options**
- **RSA usage change** to **mtp transfer data** mode
- change the usb socket

Bugs during the experiment 🐛

```
⊗ wmnlab@wmnlab-MOXALab249:~/D/bai/python$ python3 offline_analysis.py ../log_file/diag_log_20230307_130826_1bea4415694cceacf26683535a
  f16f54_Xiaomi-M2007J3SY_46692.mi2log
  Traceback (most recent call last):
    File "offline_analysis.py", line 11, in <module>
      from mobile_insight.analyzer import MyAnalyzer
  ImportError: cannot import name 'MyAnalyzer' from 'mobile_insight.analyzer' (/usr/local/lib/python3.8/dist-packages/MobileInsight-6.
  0.0-py3.8-linux-x86_64.egg/mobile_insight/analyzer/__init__.py)
⊗ wmnlab@wmnlab-MOXALab249:~/D/bai/python$ pip install --upgrade mobile_insight
  ERROR: Could not find a version that satisfies the requirement mobile_insight (from versions: none)
  ERROR: No matching distribution found for mobile_insight
```

```python
# Import MobileInsight modules
from mobile_insight.monitor import OfflineReplayer
from mobile_insight.analyzer import MsgLogger, LteRrcAnalyzer
# from mobile_insight.analyzer import MyAnalyzer
```

Condition:
- While I try to run offline_analysis.py
- Server can't run MyAnalyzer without loading

Solution:
- comment the codes related to my_analyzer

Bugs during the experiment 🐛

```
x = Signal_Strength_map(mi_ml1_df, mi_rrc_df)
⊗ 0.3s

---------------------------------------------------------------
UnboundLocalError                          Traceback (most recent call last)
/home/wmnlab/D/bai/analysis/unstable_ho_observer.ipynb 儲存格 9 in 1
----> 1 x = Signal_Strength_map(mi_ml1_df, mi_rrc_df)

/home/wmnlab/D/bai/analysis/unstable_ho_observer.ipynb 儲存格 9 in 2
     21 self.L = self.data_list(mi_ml1_df)
     22 if mi_rrc_df is not None:
---> 23     self.ho_event = self.collect_ho_event(mi_rrc_df)

/home/wmnlab/D/bai/analysis/unstable_ho_observer.ipynb 儲存格 9 in 1
    107 def collect_ho_event(self, mi_rrc_df):
--> 108     d = parse_mi_ho(mi_rrc_df)
    109     for key in d:
    110         d[key] = [x.start for x in d[key]]

/home/wmnlab/D/bai/analysis/unstable_ho_observer.ipynb 儲存格 9 in 7
     69 if serv_freq != target_freq:
     70     a,b = find_1st_before("rrcConnectionReestablishmentRequest", 1)
---> 71     others += " Inter freq. HO."
     72     if a is not None:
     73         others += " Near after RLF."

UnboundLocalError: local variable 'others' referenced before assignment
```

```python
if df["lte-rrc.t304"].iloc[i] == 1:
    end, _ = find_1st_after('rrcConnectionReconfigurationComplete')
    serv_cell, target_cell = df["PCI"].iloc[i], df['lte_targetPhysCellId'].iloc[i]
    serv_freq, target_freq = df["Freq"].iloc[i], df['dl-CarrierFreq'].iloc[i]

    others = ""
    if df["SCellToAddMod-r10"].iloc[i] == 1:
        n =len(str(df["SCellIndex-r10.1"].iloc[i]).split('@'))
        others=f'Set up {n} SCell.'
```

Condition:
- While I try to plot the unstable HO it occurs
- others haven't been defined
- Maybe some datas need this "others" parameter

Solution:
- add **others = ""** at the right position
- add at the top of the cell won't be efficient

CONCLUSIONS

Conclusions

Emotionally:

- Thanks to all the seniors for sure
- Especially appreciate 聖儒學長 , who help me a lot this semester
- I really see the theory in the textbook happen in the data, it's so doped…

Technically:

- Learn a lot of seniors' coding tips
- Learn a lot of network knowledge
- Improve the ability and speed to reed the papers

To see the HO, LTE, NR signal strength in real life via the data is really interesting. Since it's the first time I take the monographic research, …

APPENDIX
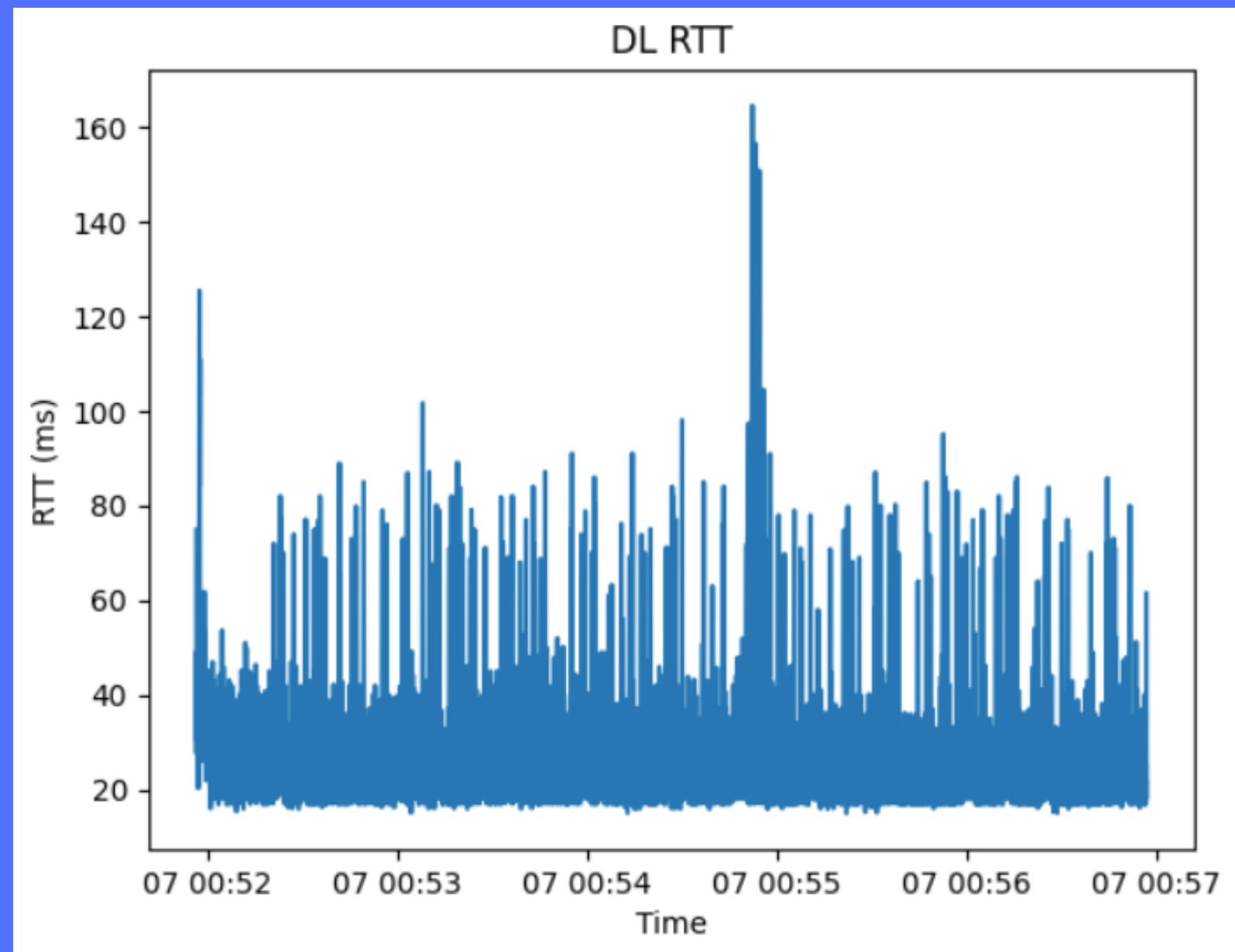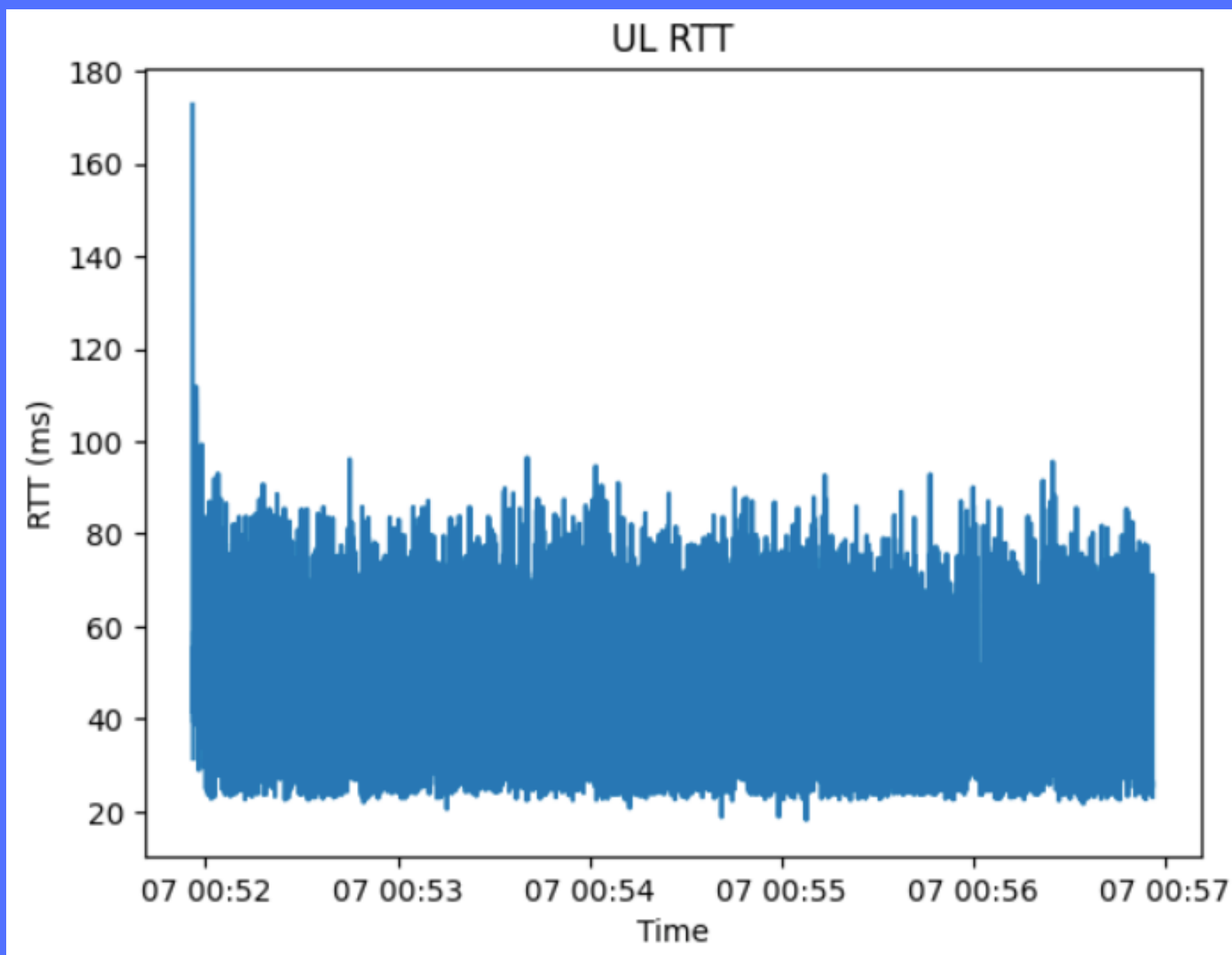
- In the dorm
- TCP

- RTT is larger at first
- Three-way handshake

- Client : SYN
- Server : SYN + ACK
- Client : ACK

- Typically 2 times
- other factors affect

LTE signal strength vs. NR

LTE_RSRP	LTE_RSRQ	NR_SSRSRP	NR_SSRSRQ
-86	-6	-	-
-88	-6	-	-
-88	-6	-	-
-88	-6	-	-
-88	-6	-	-
-88	-9	-	-
-84	-7	-89	-11
-85	-7	-89	-11
-85	-7	-90	-11
-84	-7	-90	-11
-84	-7	-90	-11
-86	-7	-93	-11
-86	-7	-93	-11

LTE_RSRP	LTE_RSRQ	NR_SSRSRP	NR_SSRSRQ
-62	-8	-67	-11
-62	-8	-67	-11
-62	-8	-67	-11
-62	-7	-67	-11
-62	-7	-67	-11
-62	-7	-67	-11
-62	-7	-68	-11
-59	-7	-68	-11
-59	-7	-68	-11

-93	-11	-76	-11
-93	-11	-76	-11
-88	-10	-76	-11
-88	-10	-75	-11
-82	-11	-75	-11
-82	-11	-71	-11
-73	-11	-71	-11
-73	-11	-71	-11
-83	-12	-78	-15
-83	-12	-78	-15
-88	-12	-78	-15
-88	-12	-78	-15
-90	-14	-89	-16
-90	-14	-89	-16

- **LTE** signal strength usually **> NR** at first
- But at the middle of the transmission **LTE** sometimes **< NR**

- It turns out to be just some **fluctuation**

THANKS