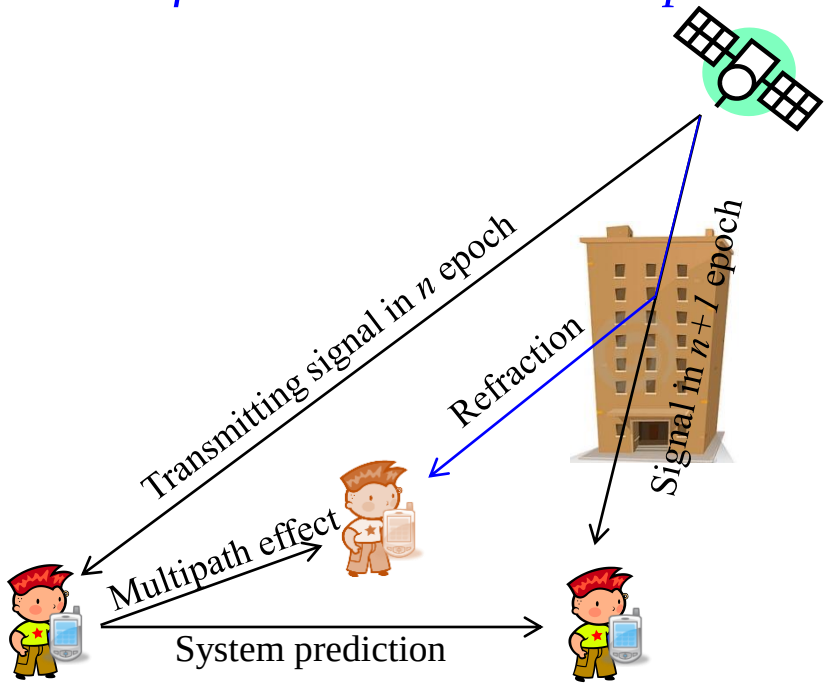
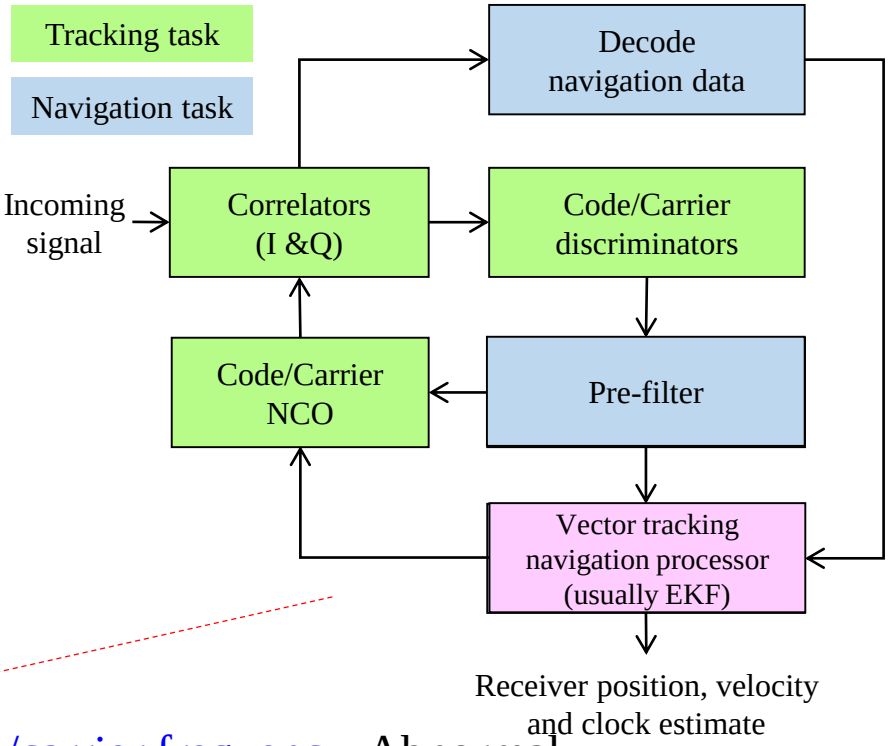
Modified Receiver processing (Vector-Tracking)

- Vector tracking is a promising approach for reducing the effect of *multipath interference* and *NLOS reception*.

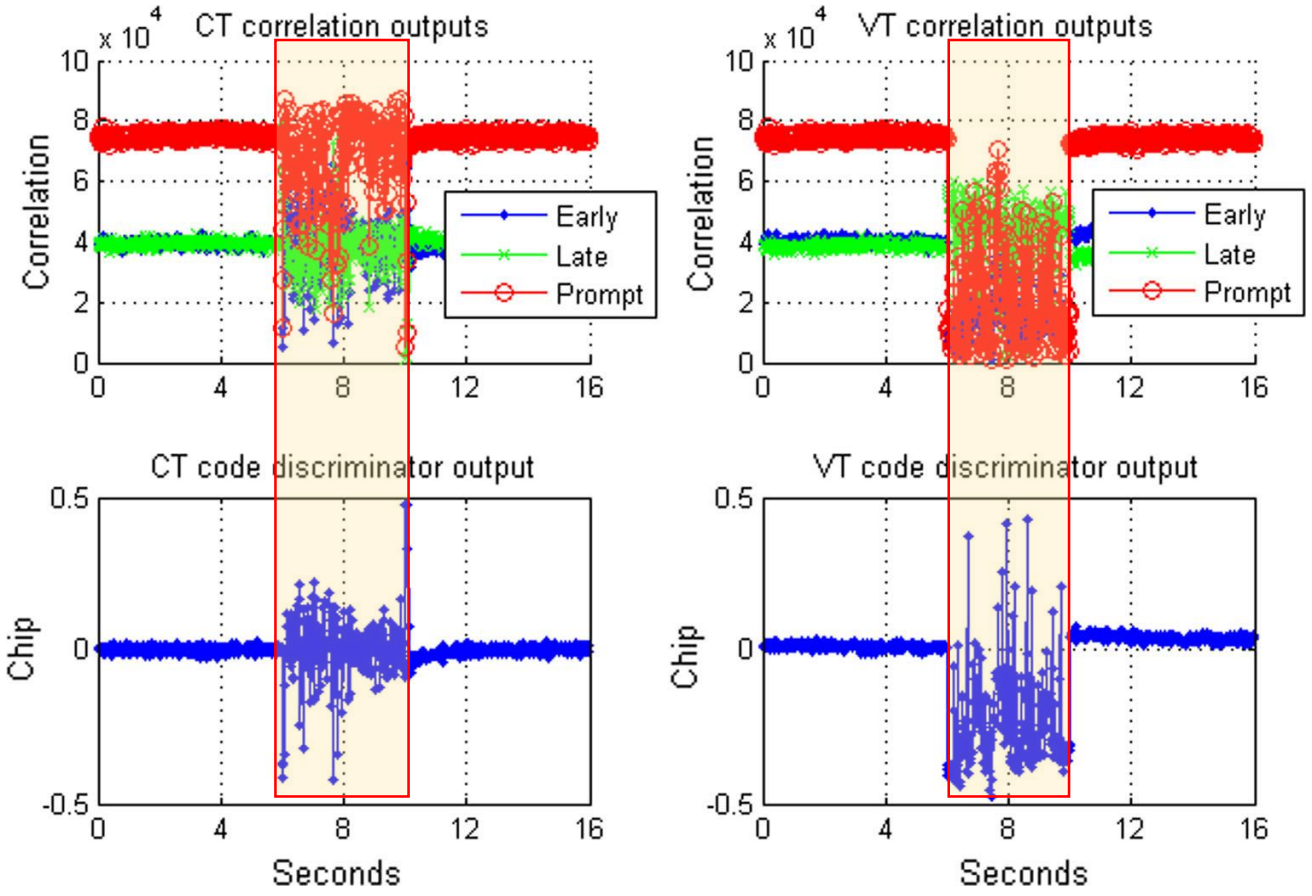




Use predicted pseudorange/rate to estimate code/carrier frequency. Abnormal measurements which caused by multipath effect can be therefore detected.

Hsu, L.-T.; Jan, S.-S.; Groves, P.; Kubo, N. Multipath mitigation and NLOS detection using vector tracking in urban environments. *GPS Solutions* 2015, 19, 249-262.

Vector Tracking Simulation Result



The correlation value in prompt channel is the highest, indicating the loop is locking onto the NLOS signal.

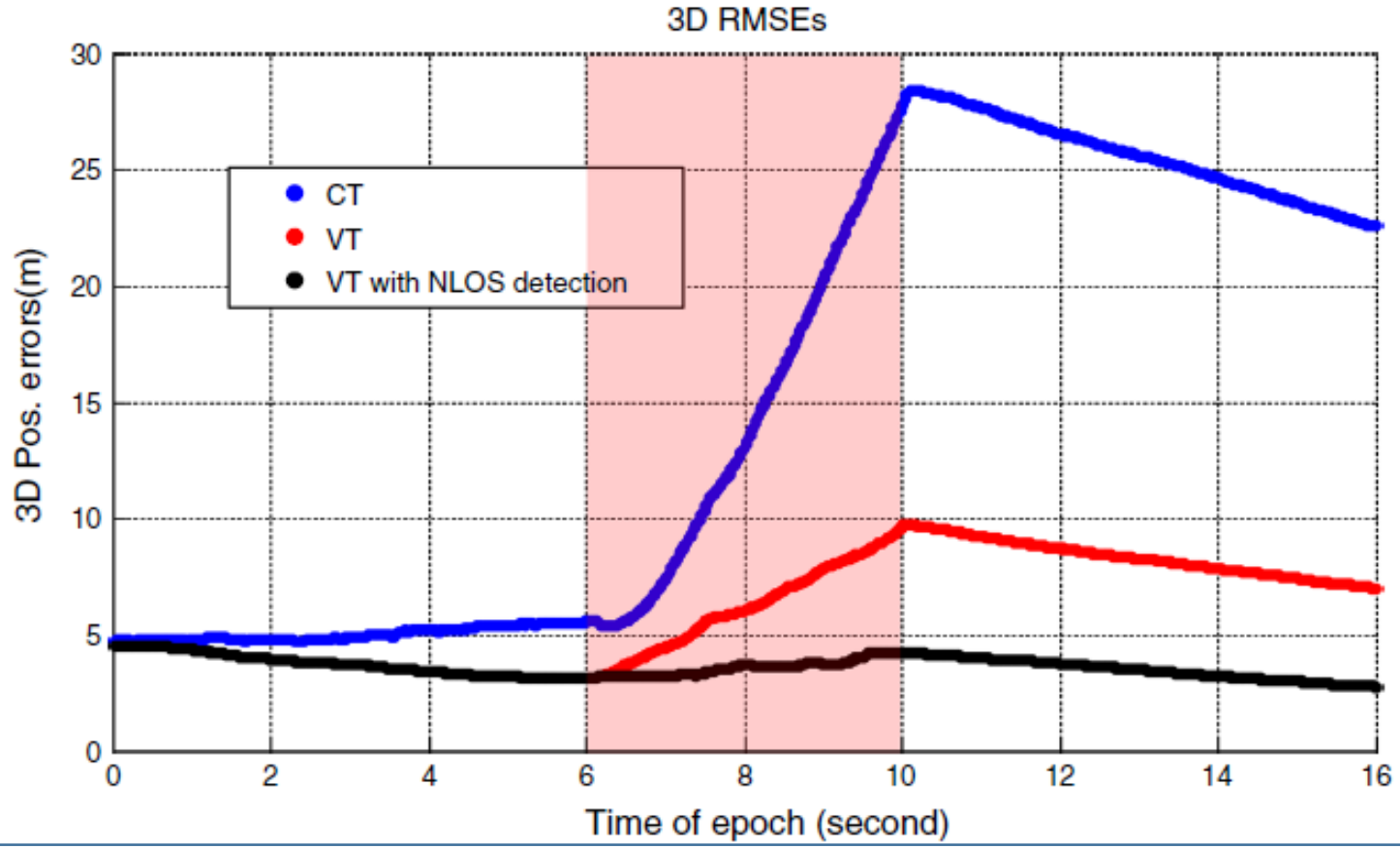
For VT, however, the highest correlation value is in the late channel.

Besides, the VT code discriminator output has a large negative value during the period of NLOS reception.

Hsu L.T., Jan S.S., Groves P.D., et al. In *Multipath mitigation and NLOS detection using vector tracking in urban environments*, GPS Solutions, 2015, 19: 249-262.

Vector Tracking Simulation Result

Three-dimensional positioning RMSE of CT, VT, and VT with NLOS detection technique



Hsu L.T., Jan S.S., Groves P.D., et al. In *Multipath mitigation and NLOS detection using vector tracking in urban environments*, GPS Solutions, 2015, 19: 249-262.

Experiment Setup – Utilities

Estimate accurate position

Easily receive multipath signal

Novatel SPANCPT

Novatel L1 active airborne antenna

GPS networking Antenna Splitter

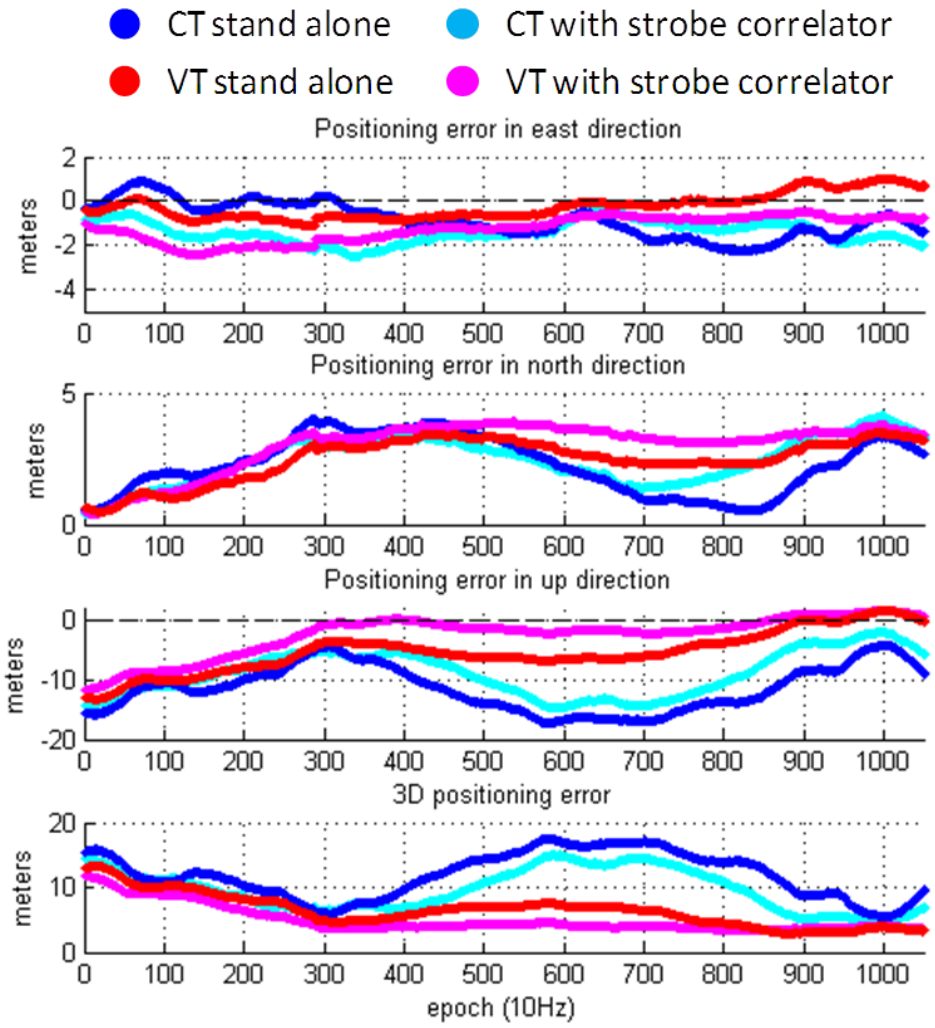
Record IF signal

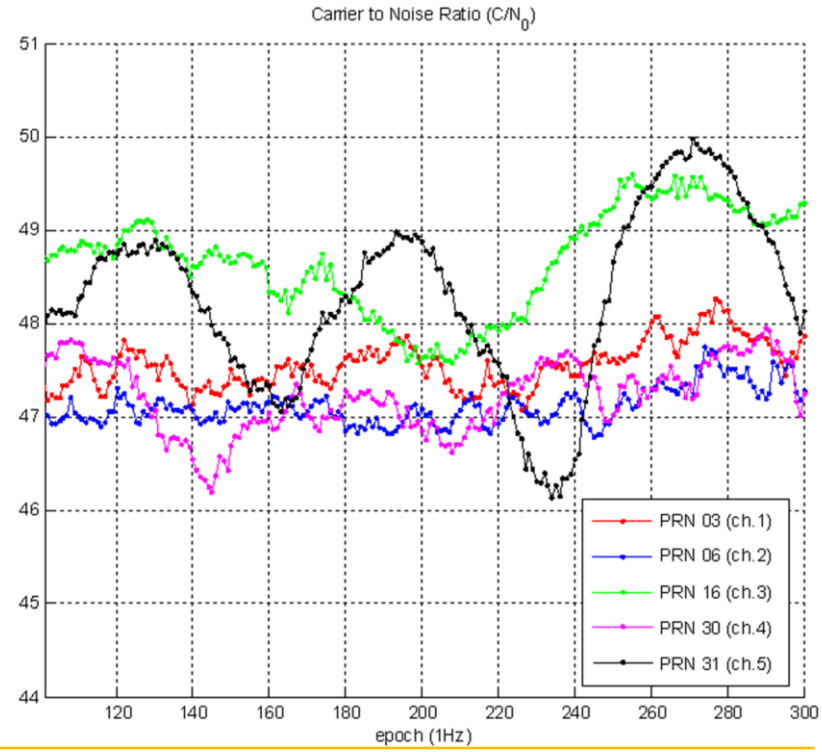
IP Solutions front-end

Laptop

F_s:	16.367667MHz
F_{IF}:	4.1304MHz

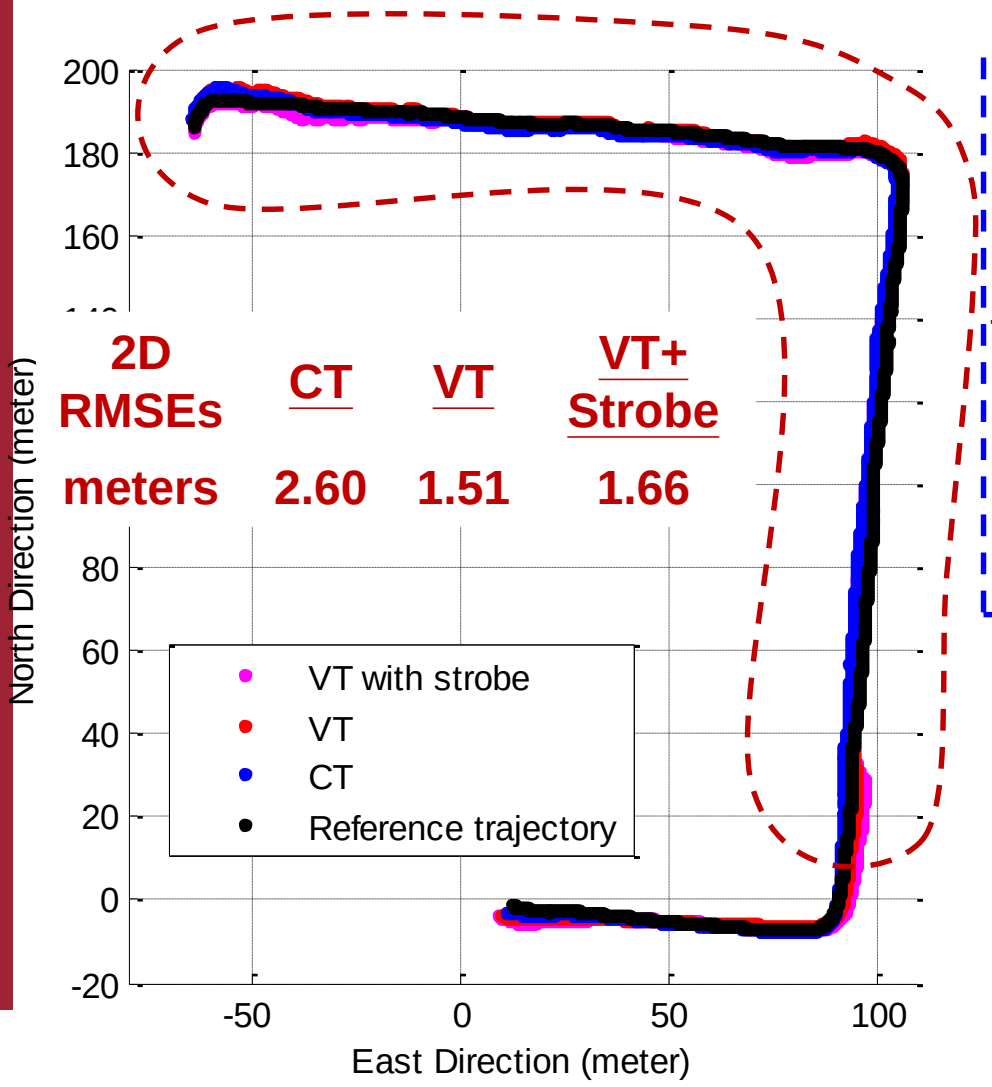
NCKU Static Experiment Results

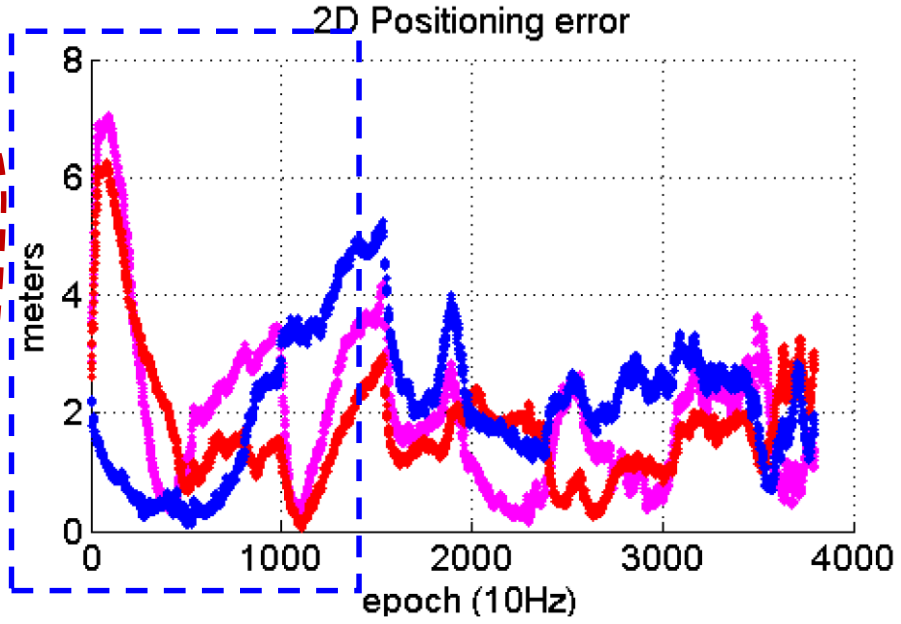




Methods	RMSE (meters)
VT	6.43
CT	11.84
VT + Strobe correlator	4.98
CT + Strobe correlator	9.60

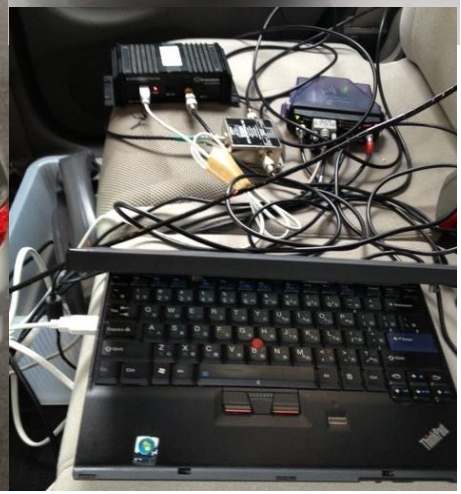
Experiment Results – Positioning Results





VT requires an amount of time to optimize its performance through self-calibration.

Experiment Setup of Tokyo Test



NovAtel 702 Antenna

GPS networking
Signal splitter

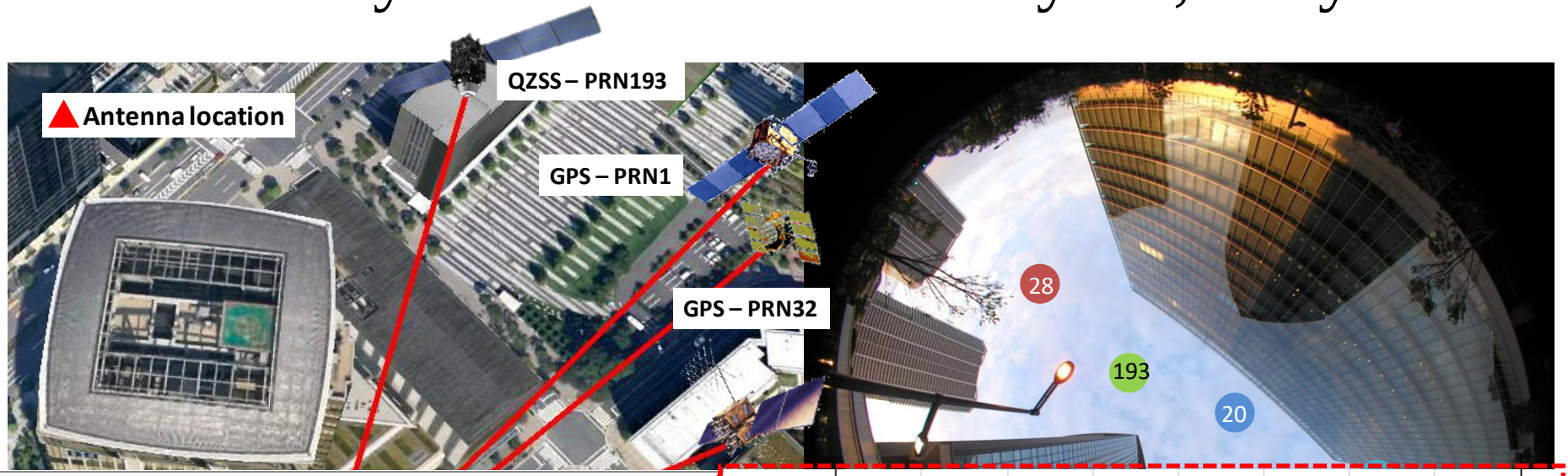
NovAtel OEM6

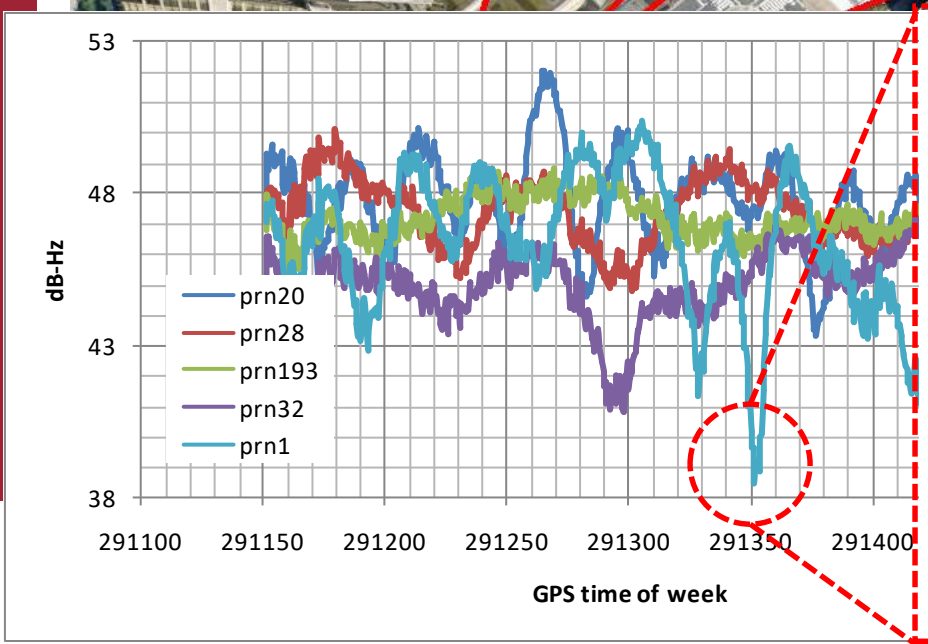
Fraunhofer front-end

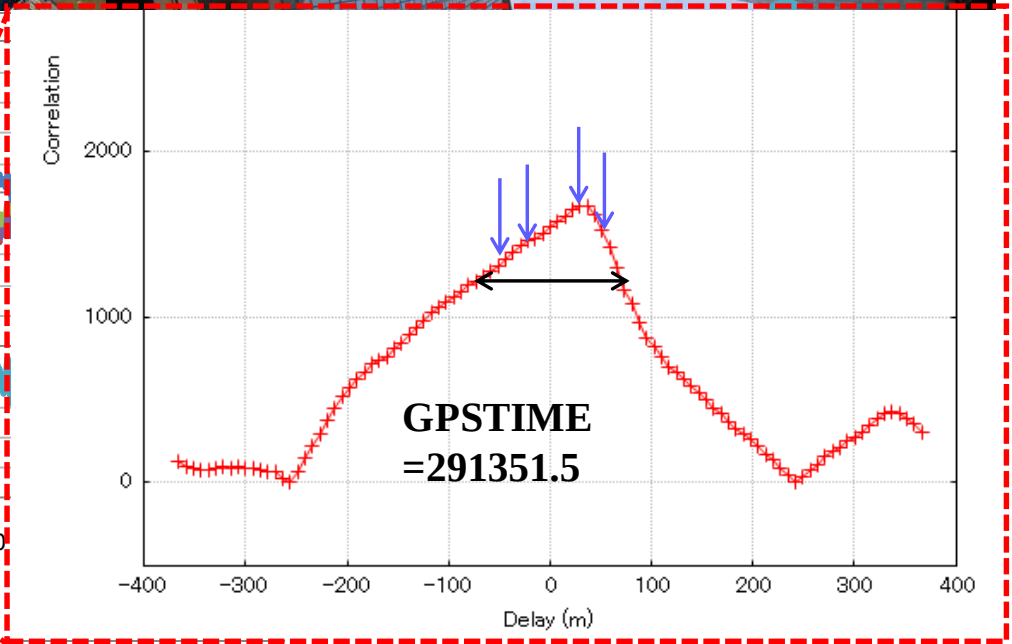
F_s:	40.96 MHz
F_{IF}:	12.82 MHz

Panasonic Laptop

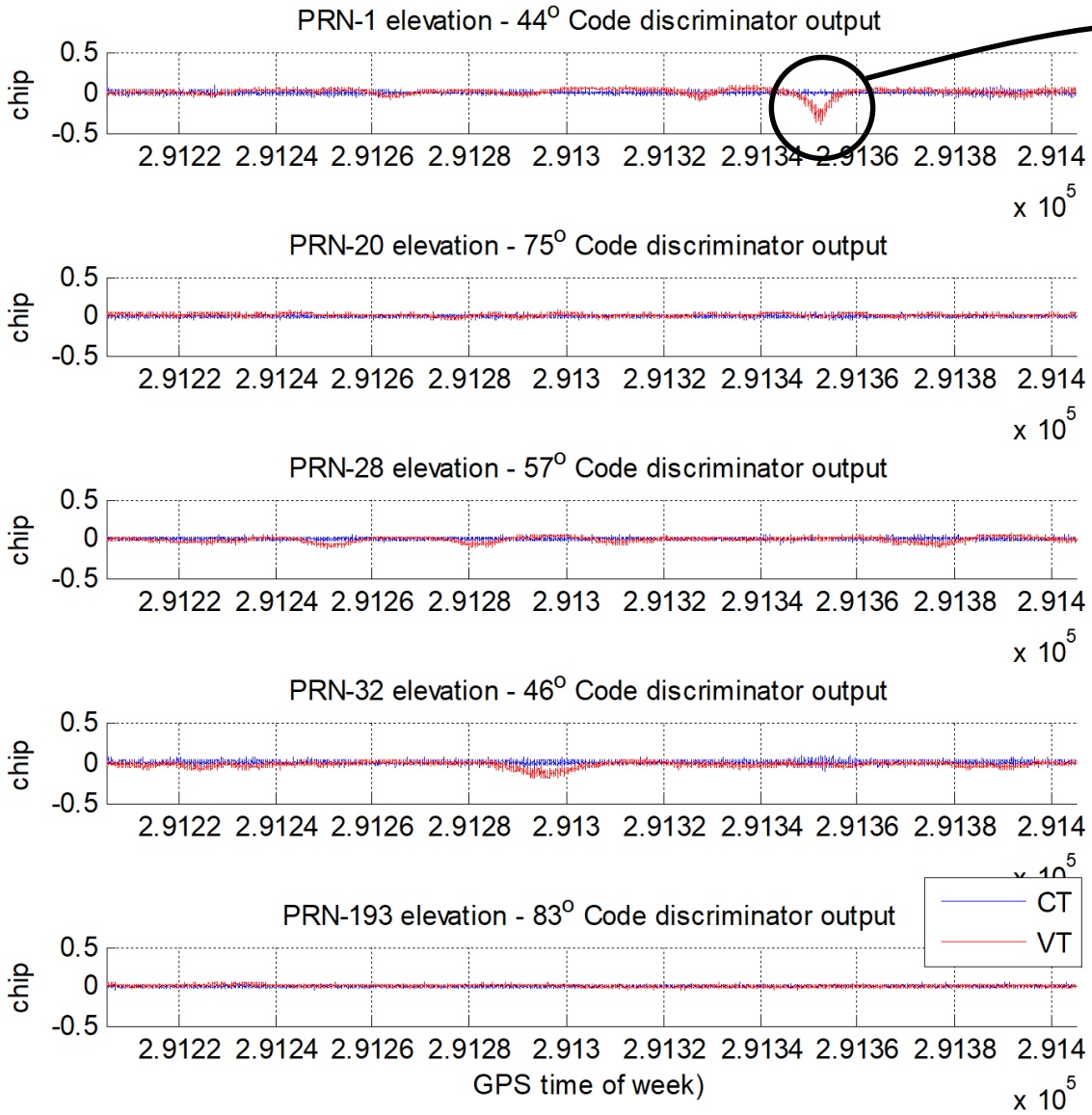
Urban Canyon Environment at Toyosu, Tokyo

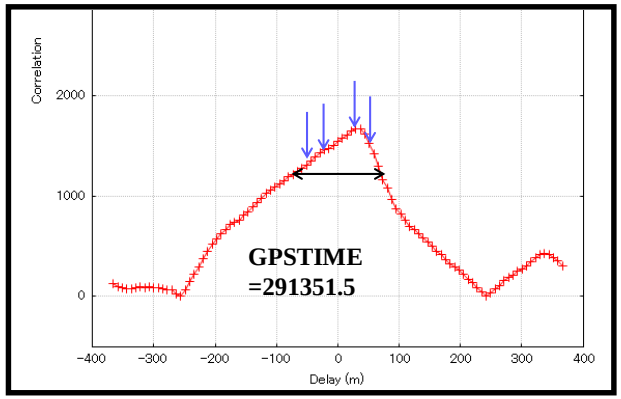






Code Discriminator Outputs in Tokyo Tests



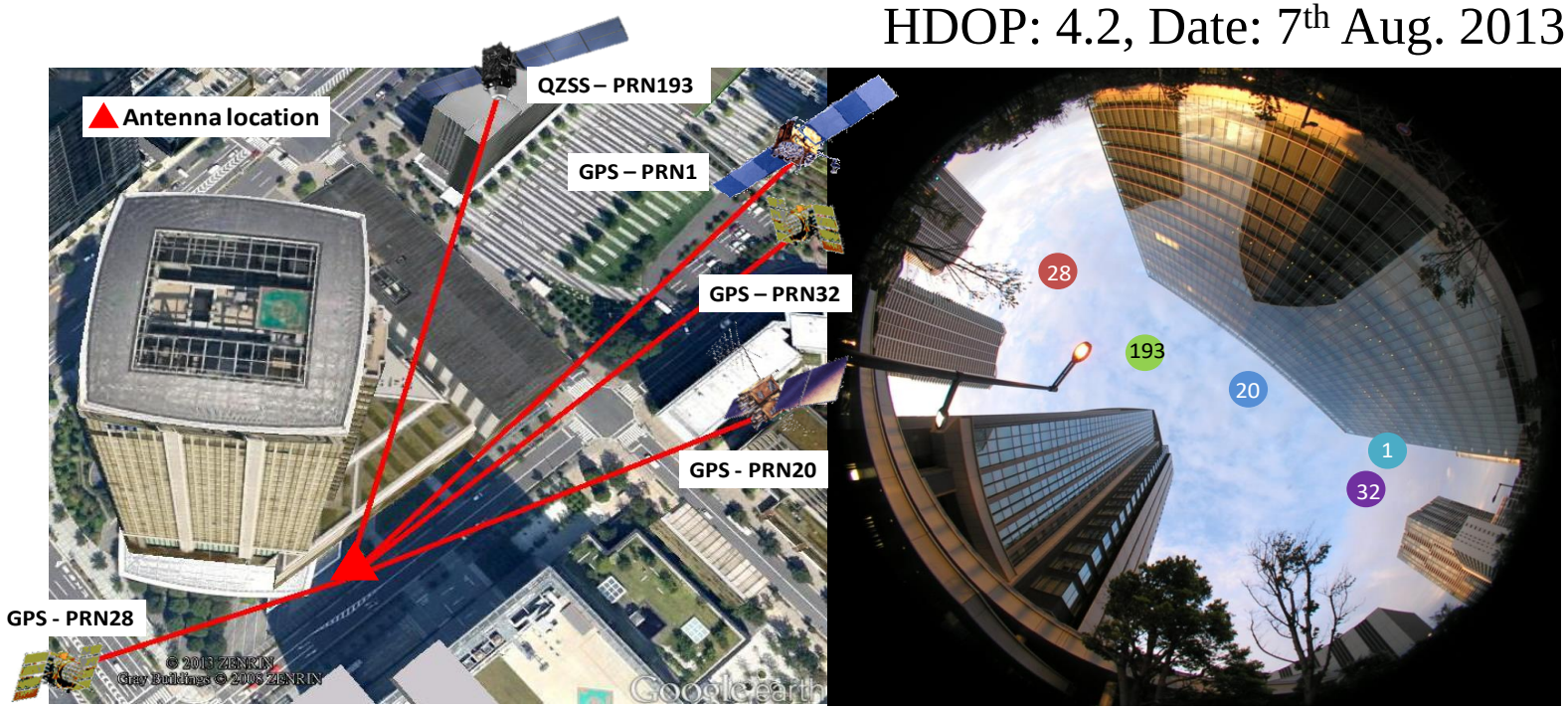


The peak of VT's code discriminator output detects the demonstrated multipath effect!

Lower elevation angle usually come with stronger multipath interference!

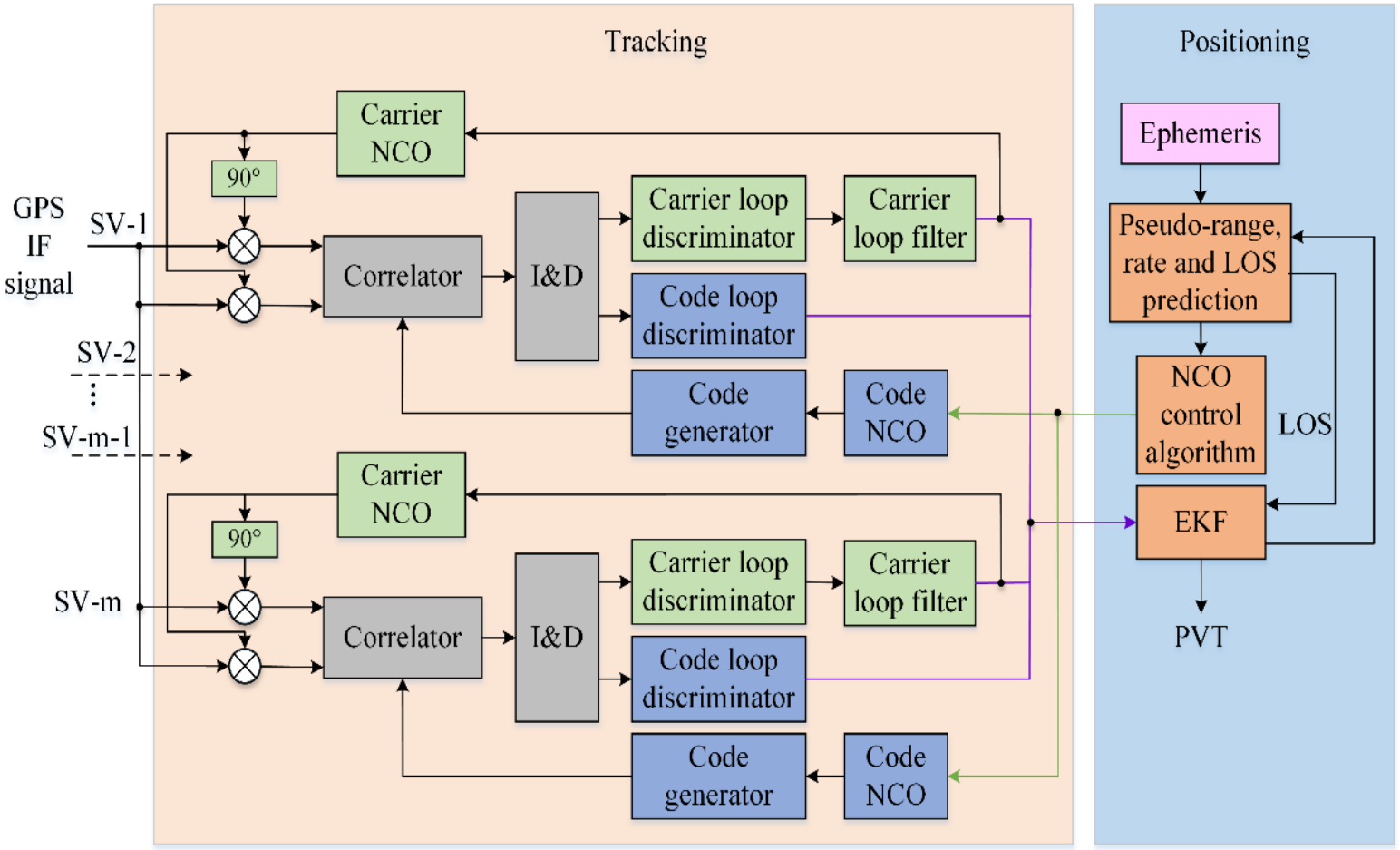
Positioning Performance at Tokyo, Japan

HDOP: 4.2, Date: 7th Aug. 2013



Approaches	Mean (meters)	Std (meters)
Standard positioning	30.20	20.24
Standard positioning using strobe correlator (0.3,0.15)	19.47	14.55
Vector tracking	**9.51**	**4.09**
Vector tracking + strobe correlator (0.3,0.15)	**8.66**	**4.34**

We will open-source this Vector Tracking Matlab Code Soon



B Xu and LT Hsu, An Open Source Matlab Code on GPS Vector Tracking based on Software-Defined Receiver, *GPS Solutions*, (to be submitted)