



Kartverket

FFI Forsvarets
forskningsinstitutt
Norwegian Defence Research Establishment

How does radio-frequency interference (RFI) influence network RTK?

Results of a field test in Norway

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Norwegian Defence Research Establishment

Göteborg, Sweden • 3 September 2014

MOTIVATION

Massive GPS Jamming Attack by North Korea

May 8, 2012 - By GPS World staff



Jersey Jammer Caper

Privacy Precludes GPS



JAMMING CELL PHONES AND GPS EQUIPMENT IS AGAINST THE LAW!



The Economist

The Economist

GPS jamming Out of sight

Satellite positioning-data are vital—but the signal is surprisingly easy to jam
Jul 27th 2013 | From the print edition

Technology Quarterly:
Q1 2011

GPS jamming No jam tomorrow

Navigation: As the uses of satellite-positioning technology continue to grow, what can be done to stop deliberate and dangerous jamming of the signals?

Mar 10th 2011 | From the print edition
Email: mark.wignfield@fcc.gov



NEWS

Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

This is an unofficial announcement of Commission action. Release of the full text of a Commission order constitutes an official action. See MCI v. FCC, 515 F.2d 385 (D.C. Cir. 1974).

FOR IMMEDIATE RELEASE:
June 19, 2014

FCC PLANS \$34.9 MILLION FINE

AGAINST CHINESE ONLINE RETAILER OF SIGNAL JAMMING DEVICES

Warns U.S. Consumers that Importing and/or Operating a Signal Jammer is Unlawful

The Hunt for RFI: Unjamming a Coast Harbor

by Gps World Staff • 11 min read • original

RADIO-FREQUENCY INTERFERENCE (RFI) – WHAT IS IT?

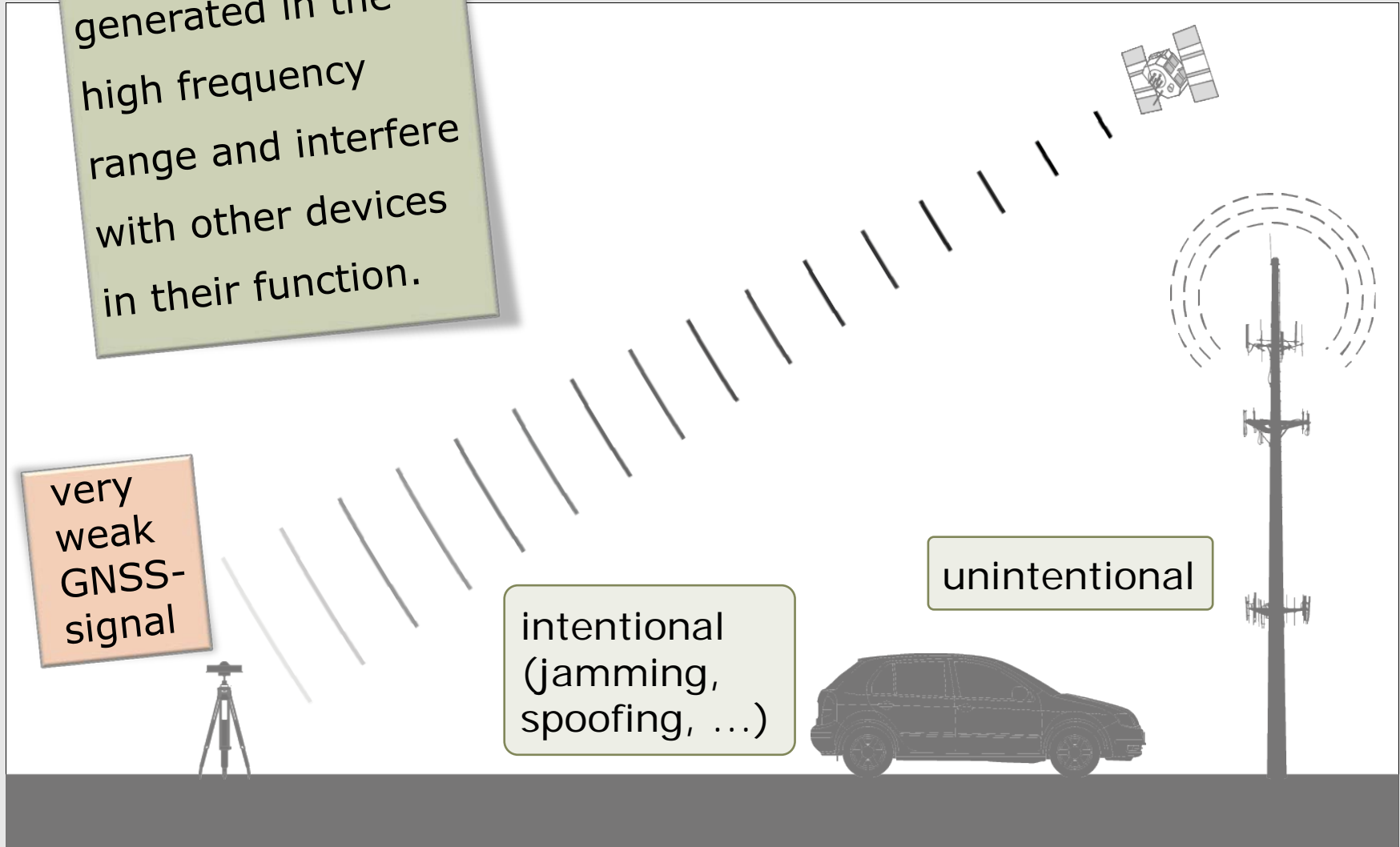
RFI:

Disorders,
generated in the
high frequency
range and interfere
with other devices
in their function.

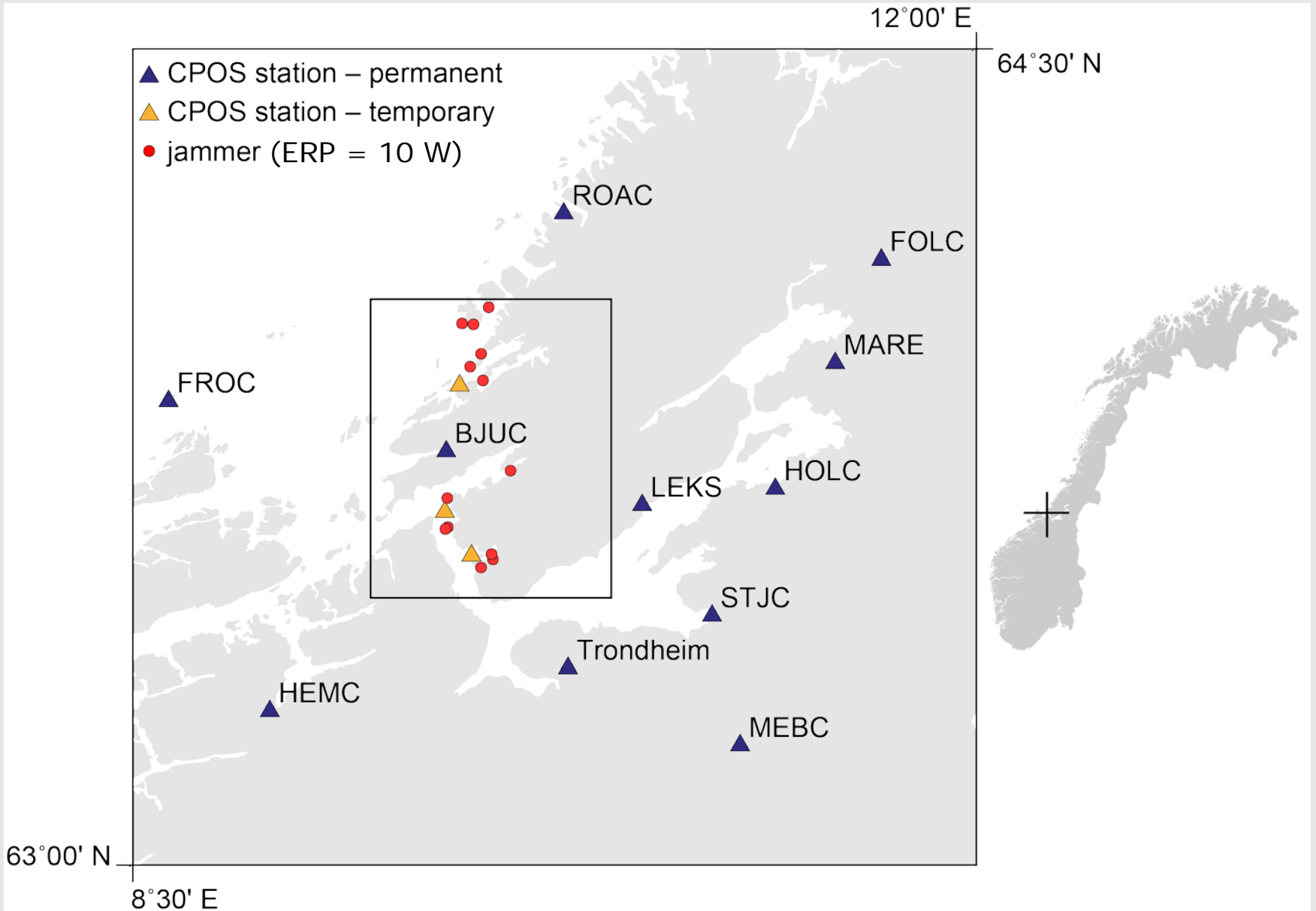
very
weak
GNSS-
signal

intentional
(jamming,
spoofing, ...)

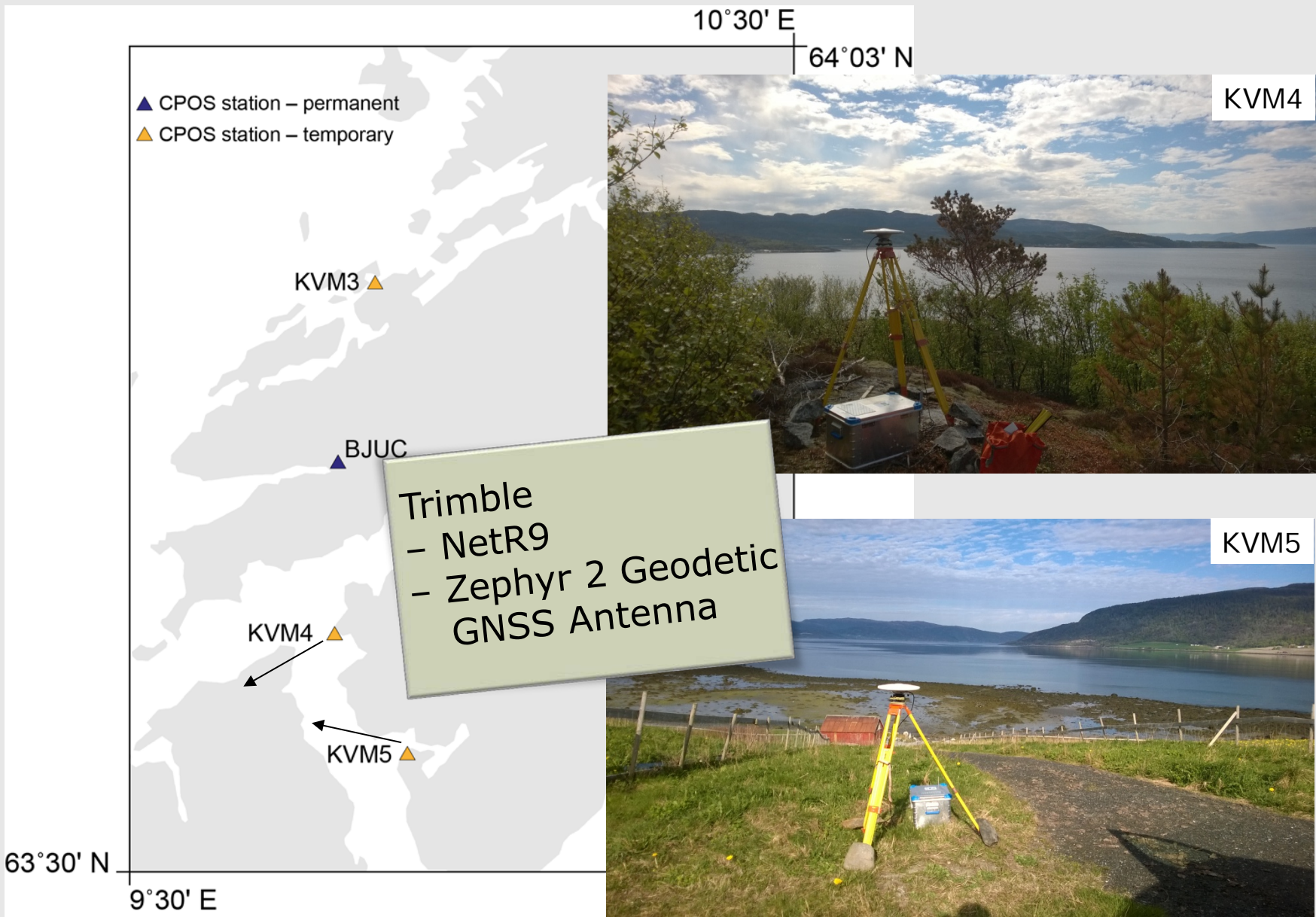
unintentional



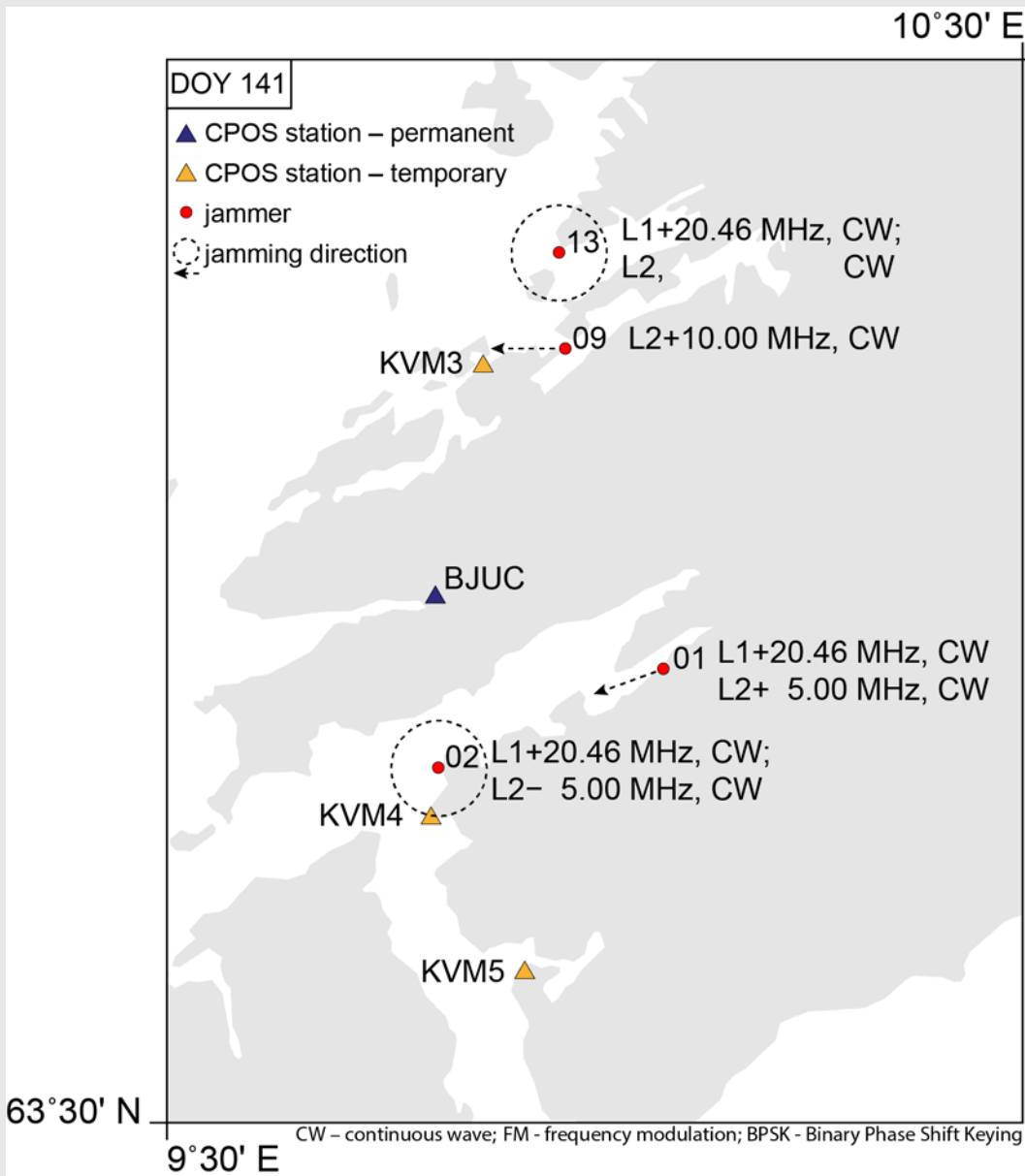
TEST AREA – UNIFIED VISION 2014



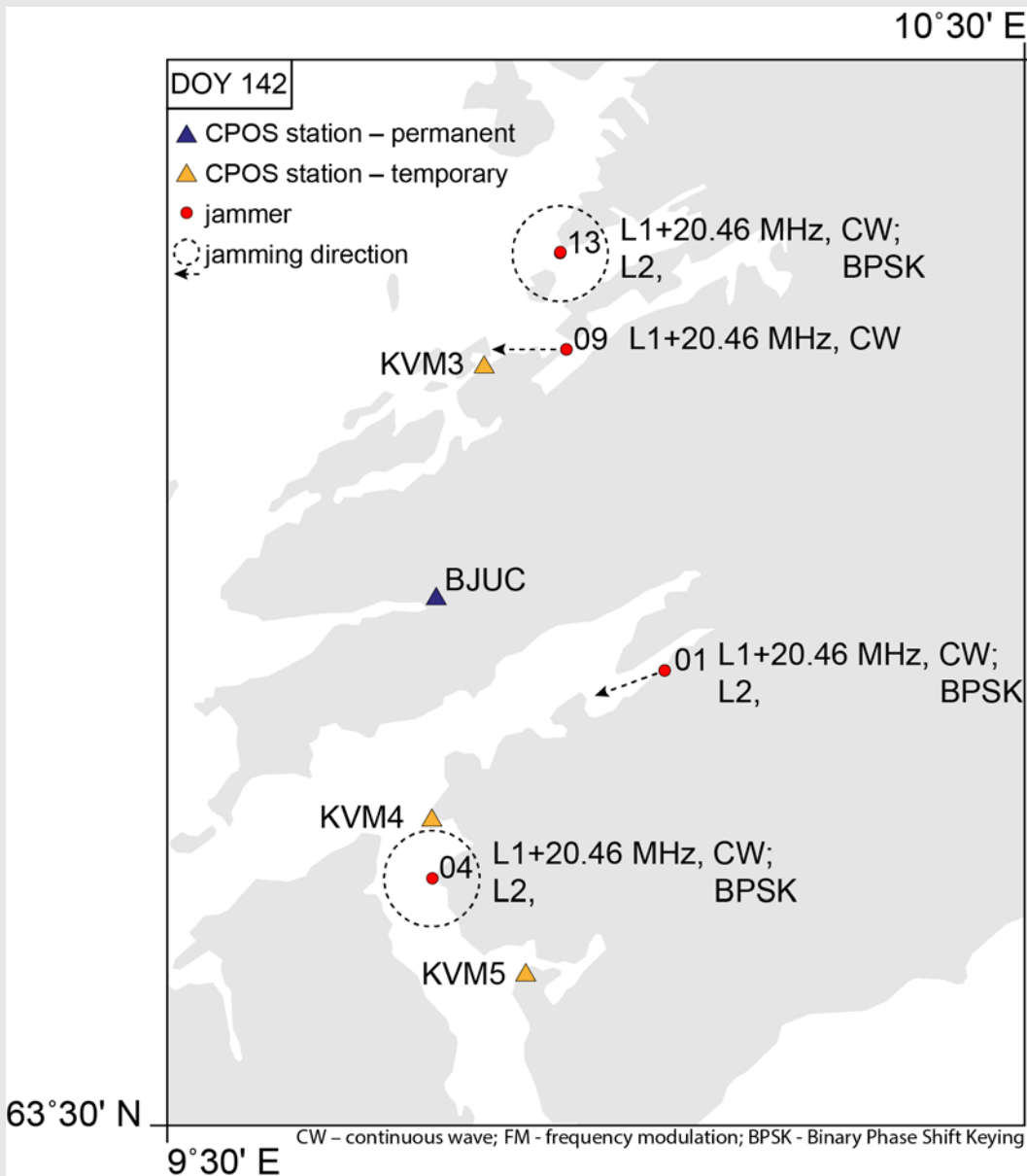
TEST AREA – JAMMING UV14 – #1



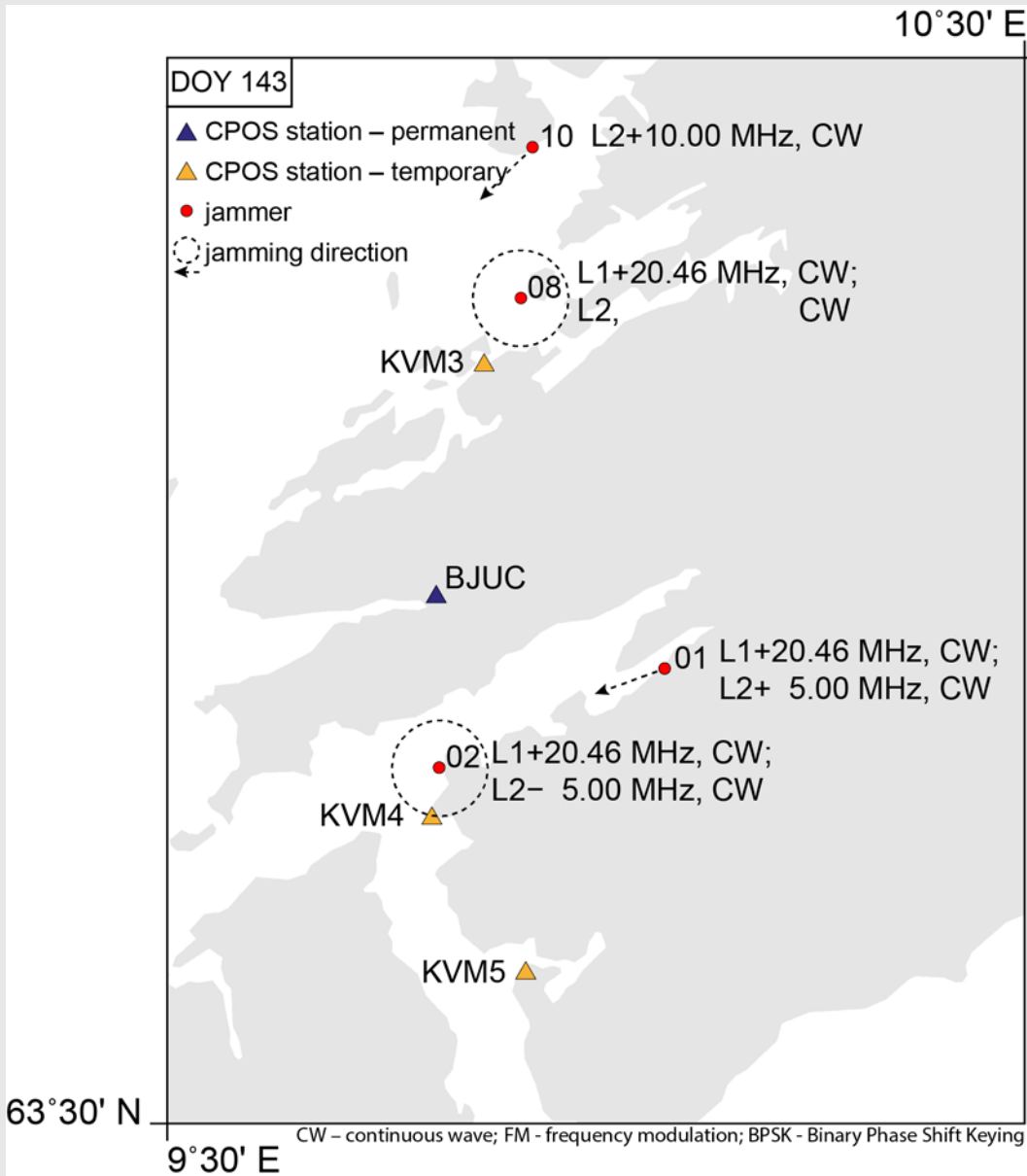
TEST AREA – JAMMING UV14 – #2



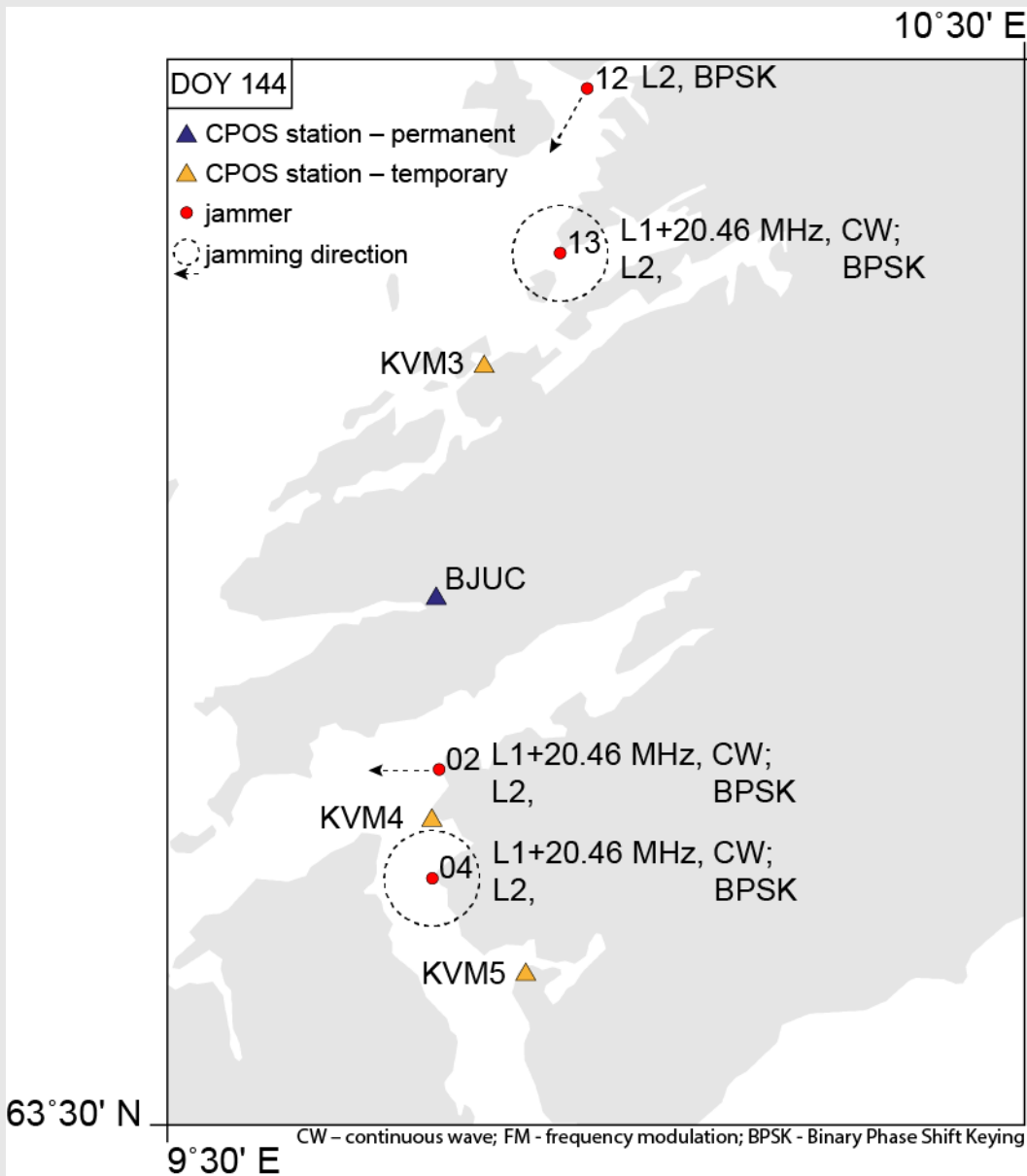
TEST AREA – JAMMING UV14 – #3



TEST AREA – JAMMING UV14 – #4



TEST AREA – JAMMING UV14 – #5



TRIMBLE PIVOT PLATFORM V.3.1.3

Network processing of 29 reference stations

Trimble Pivot Platform [FFI]

- Device Manager [Default]
 - GNSS Receiver [Bjugn]
 - GNSS Receiver [Bleikvassli]
 - GNSS Receiver [Donna]
 - GNSS Receiver [Folling]
 - GNSS Receiver [Froya]
 - GNSS Receiver [Grong]
 - GNSS Receiver [Hemavan]
 - GNSS Receiver [Hemme]
 - GNSS Receiver [Holasen]
 - GNSS Receiver [Kallsedet]
 - GNSS Receiver [KVM3]
 - GNSS Receiver [KVM4]
 - GNSS Receiver [KVM5]
 - GNSS Receiver [Lauvsnes]
 - GNSS Receiver [Leksvik]
 - GNSS Receiver [Lierne]
 - GNSS Receiver [Mare]
 - GNSS Receiver [Mebonden]
 - GNSS Receiver [Mosjoen]
 - GNSS Receiver [Namsos]
 - GNSS Receiver [Roan]
 - GNSS Receiver [Røyrvik]
 - GNSS Receiver [Stjordal]
 - GNSS Receiver [Storlien]
 - GNSS Receiver [Terrak]
 - GNSS Receiver [Trofors]
 - GNSS Receiver [Trondheim]
 - GNSS Receiver [Vega]
 - GNSS Receiver [Vikna]
- Disk Watch [Default]
- Ephemeris Download [Default]
- Ephemeris Manager [Default]
- Rover Integrity [FFI test]
- Synchronizer [FFI]
- Network Motion Engine [Default]
- Integrity Monitor [FFI RTK Engine]
- Network Processor RTK [FFI]**
- Network Processor Storage [FFI]
- Rapid Motion Engine [Default]
- Integrity Monitor [FFI RTK Engine]
- RTK Engine [FFI]**
- Integrity Monitor [FFI RTK Engine]**

Map 2D | Current Displacements | Adjustment | Displacement Chart | Scatter Plot | Axis Rotations | NMEA Output | FFT Results

200000 m

Type	Event Time [UTC]	Source	Group	Message Text
RTD	10.06.2014 07:47:40	Single Stati	Communication	TCP/IP Server driver could not listen for incoming connections

Network-Processor Status

network information, e.g. number of tracked and solved satellites, I95-index ...

Integrity Monitor RTK Engine

detect significant movement of GNSS station

NETWORK PROCESSOR STATUS #1

expected vs. observed data

90%

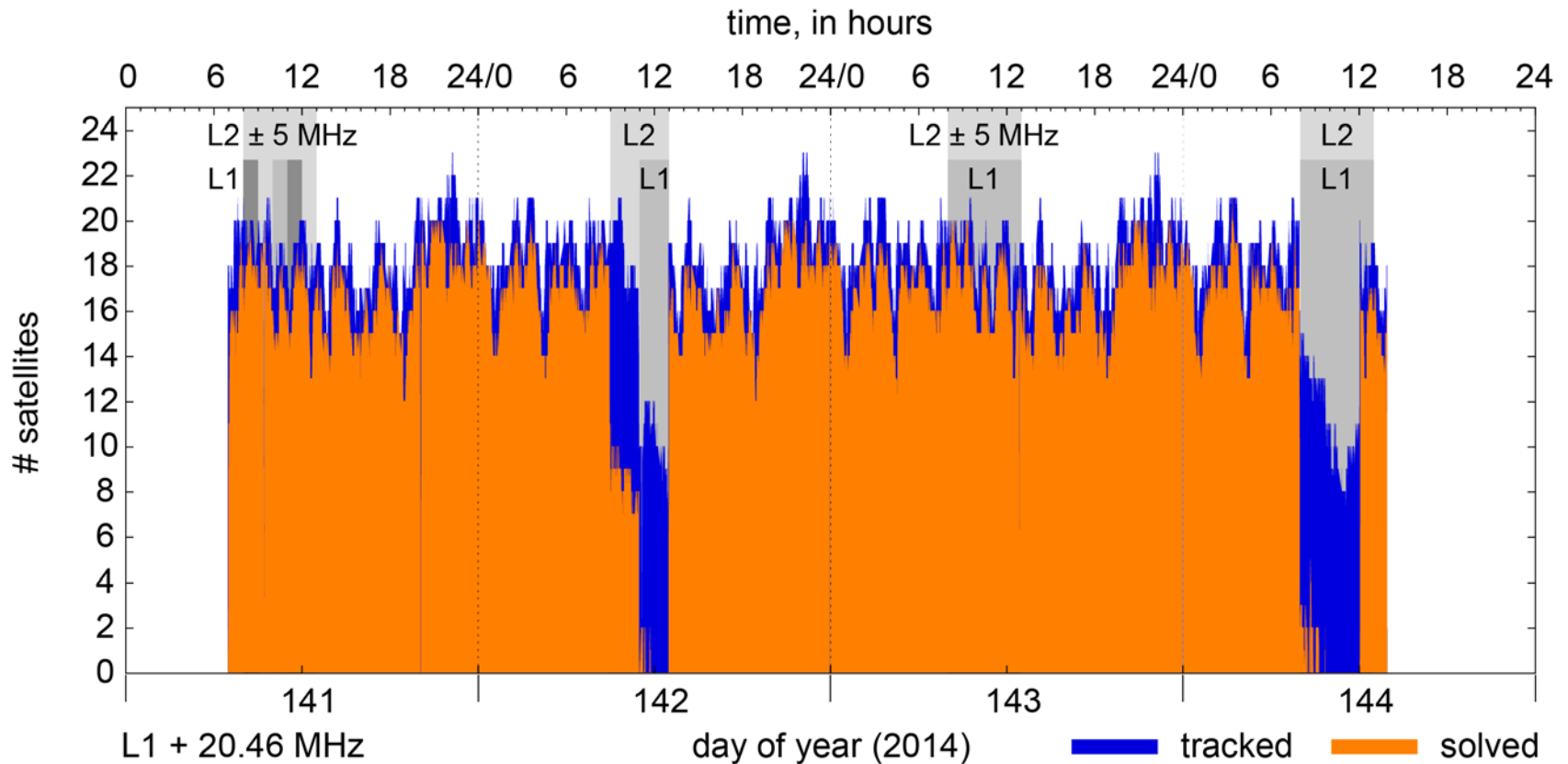
81%

90%

68%

KVM4

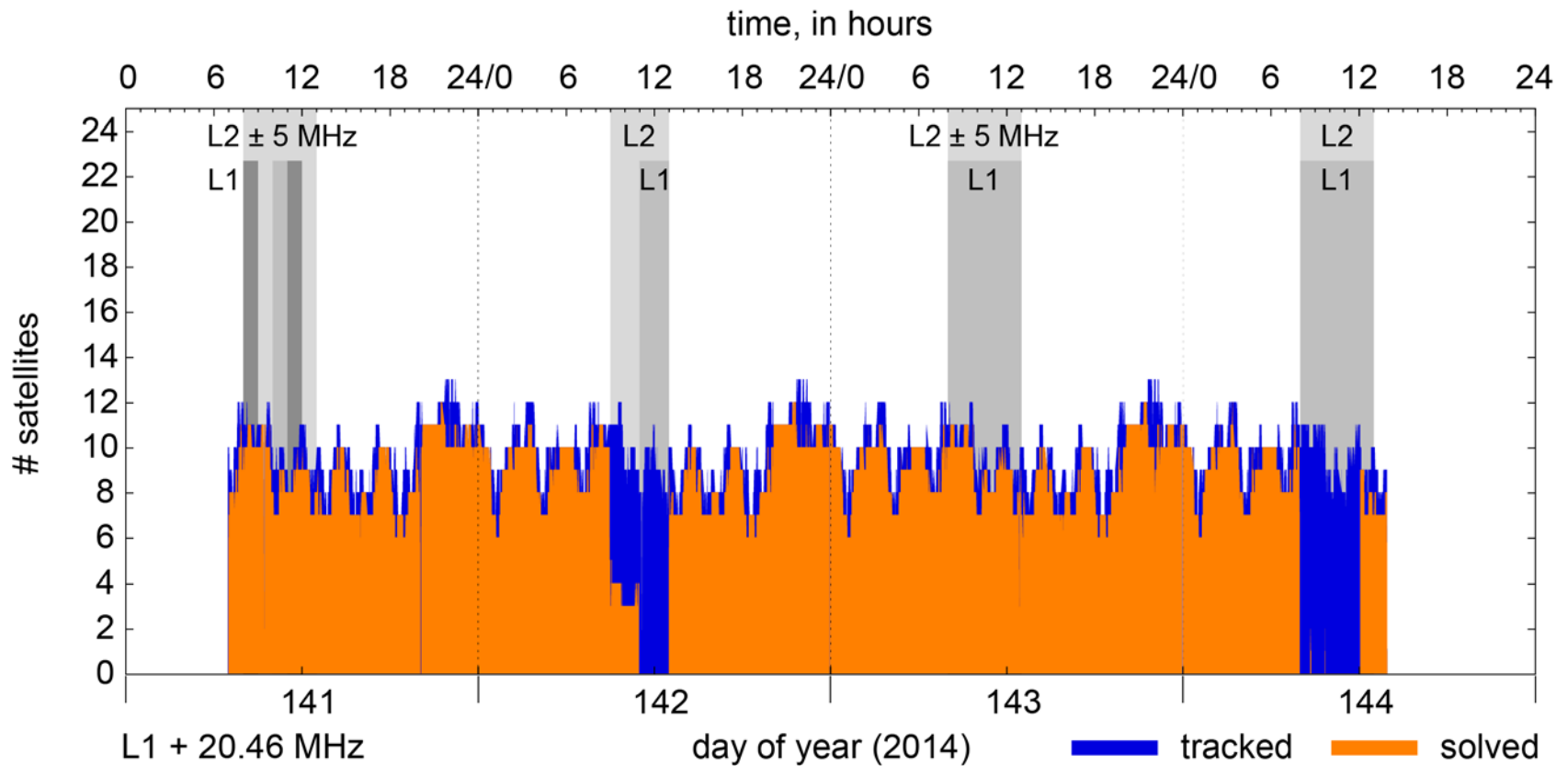
tracked vs. solved | GPS + GLONASS



NETWORK PROCESSOR STATUS #2

KVM4

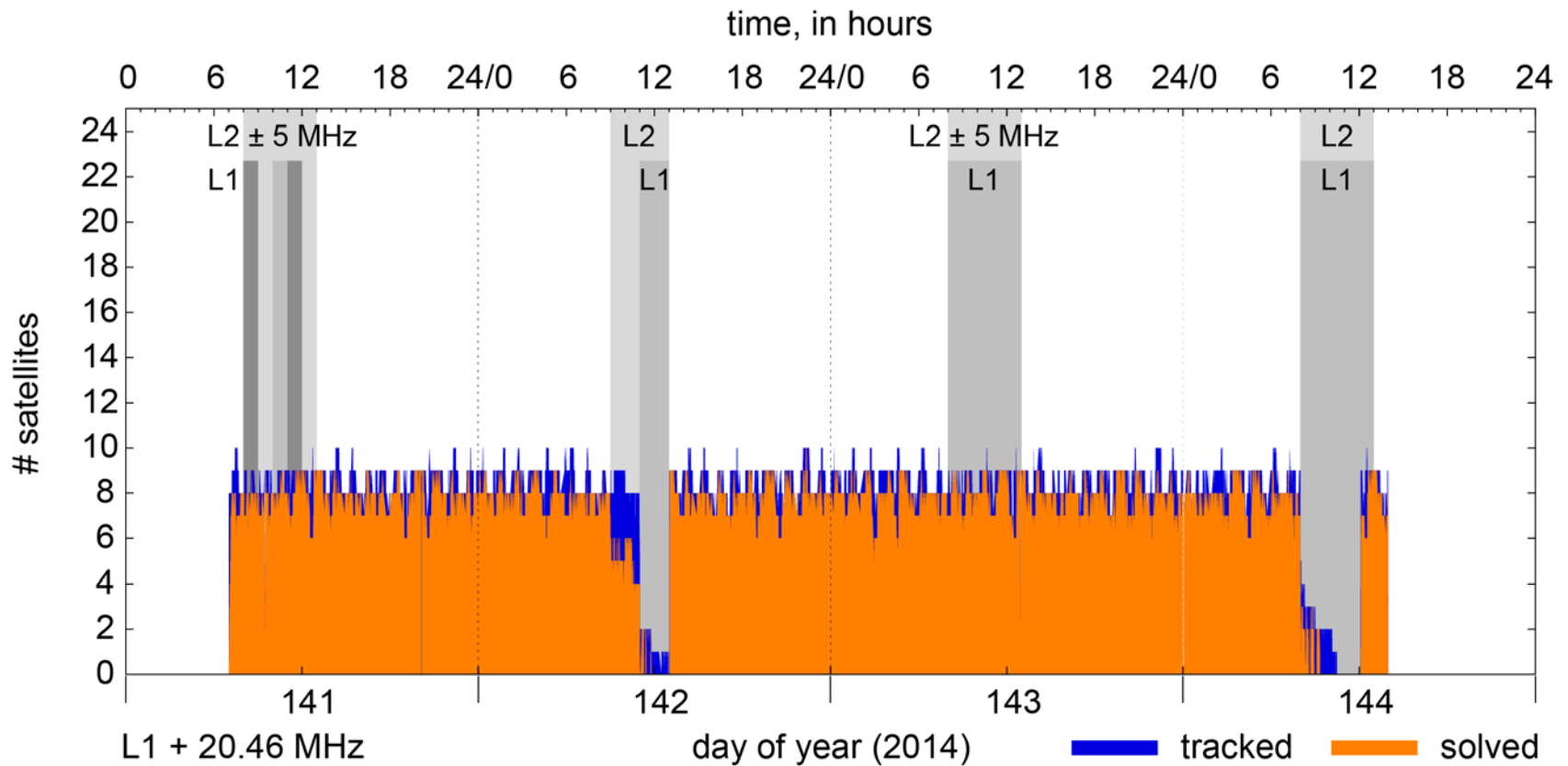
tracked vs. solved | GPS



NETWORK PROCESSOR STATUS #3

KVM4

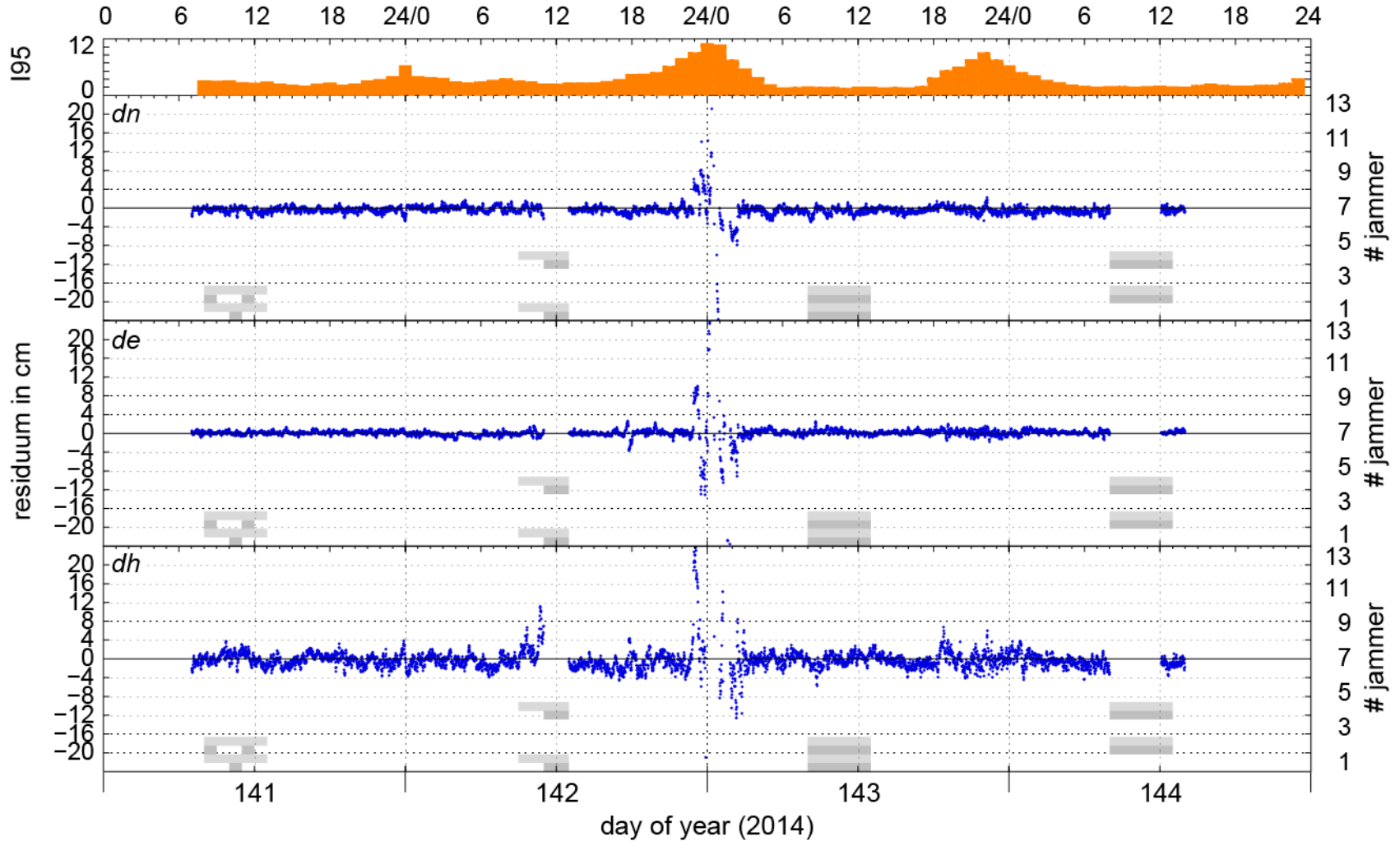
tracked vs. solved | GLONASS



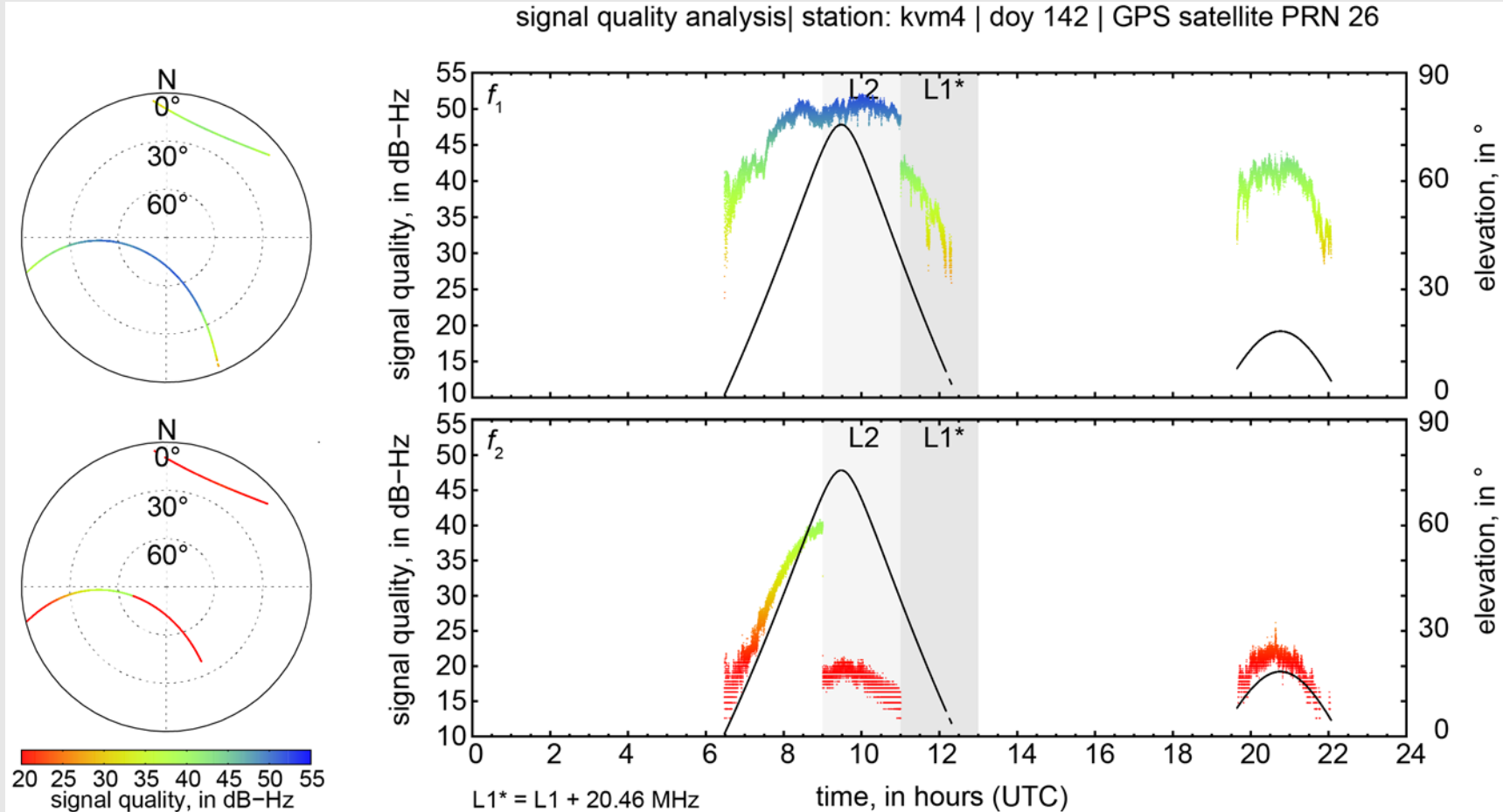
INTEGRITY MONITOR RTK-ENGINE

mean positioning integrity monitor (TPP RTKengine) | kvm4

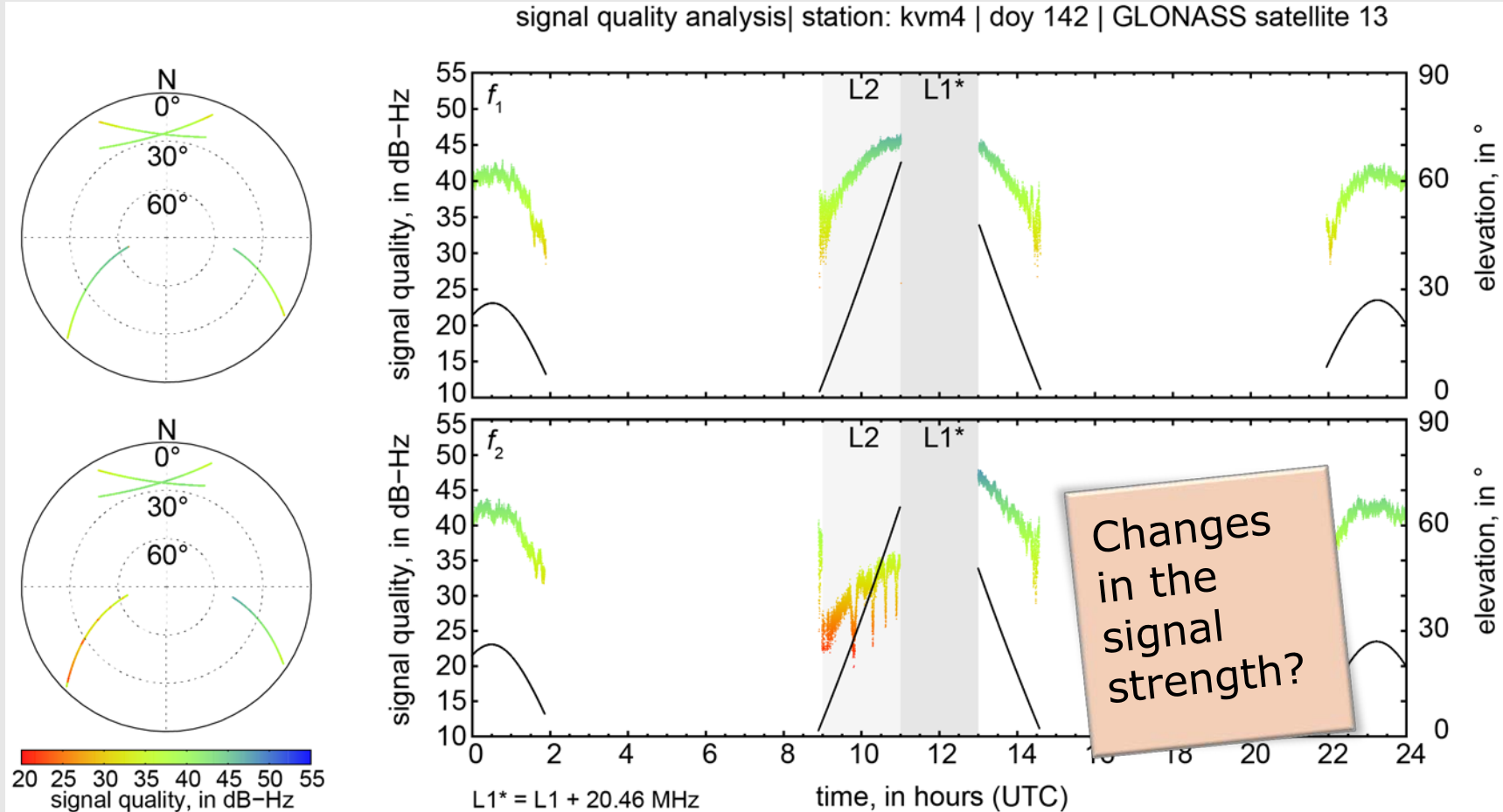
time, in hours (UTC)



SIGNAL QUALITY VS. JAMMING #1

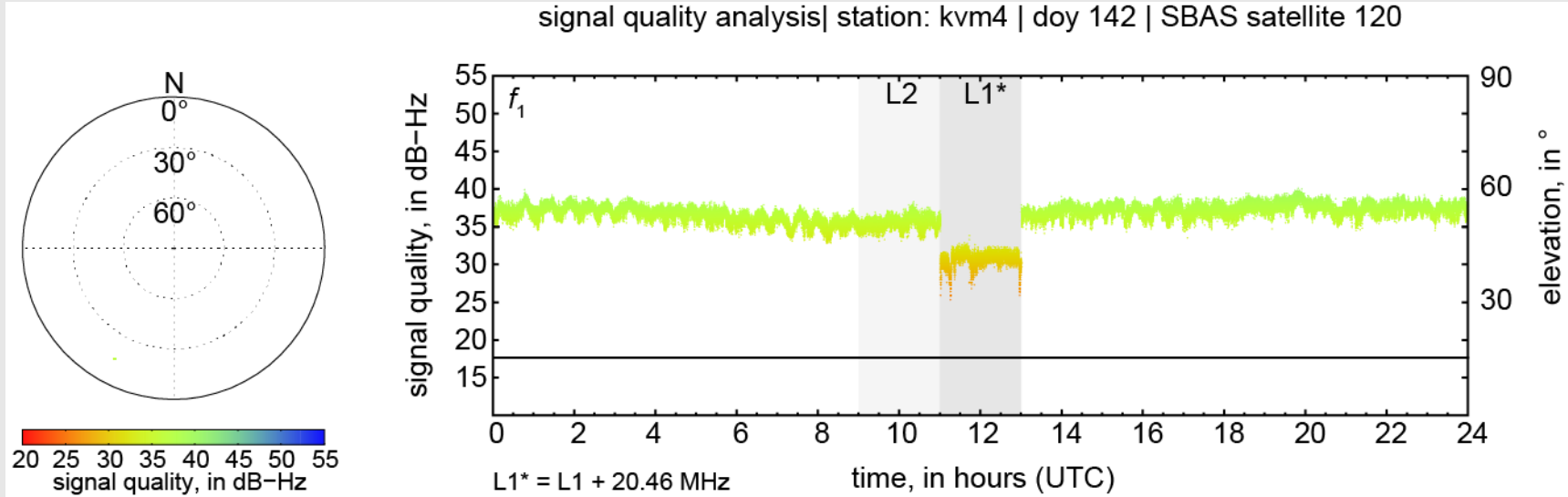


SIGNAL QUALITY VS. JAMMING #2



$$f_1 = 1600.8750 \text{ MHz}; f_2 = 1245.1250 \text{ MHz}$$

SIGNAL QUALITY VS. JAMMING #3



CONCLUSION

- threatening effect on the network RTK service performance if the jammer is close and strong enough
- two frequency data are mandatory for network RTK service
- outage of a reference station deteriorates e.g. the quality of virtual reference station (VRS) data
- receiver performance degradation if jamming occurs

frequency diversity

dense station network

hardening GPS receivers and antennas

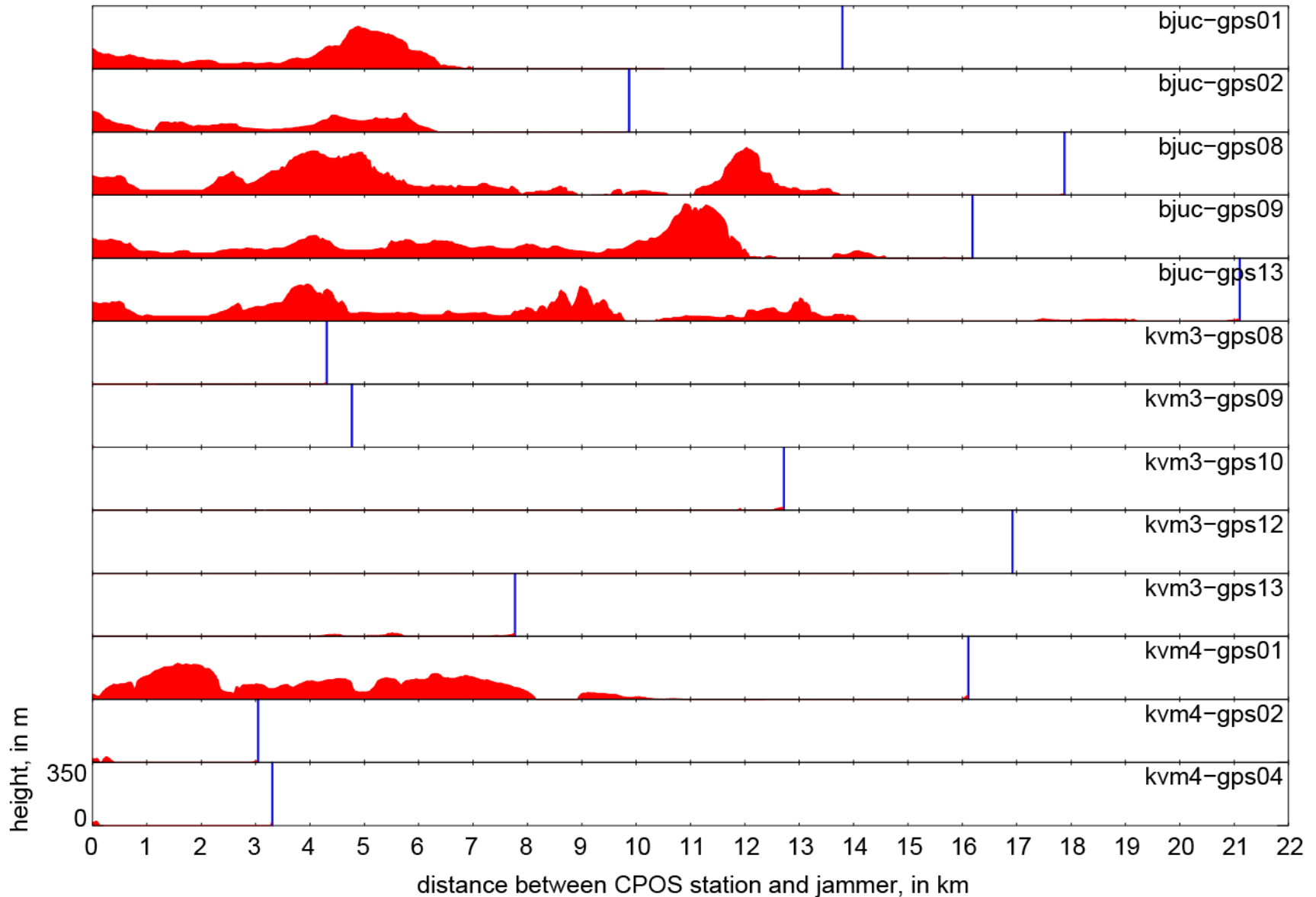
establishing GNSS backups

Questions?

Comments?

APPENDIX

HEIGHT PROFILE



NETWORK PROCESSOR STATUS #4

expected vs. observed data

90%

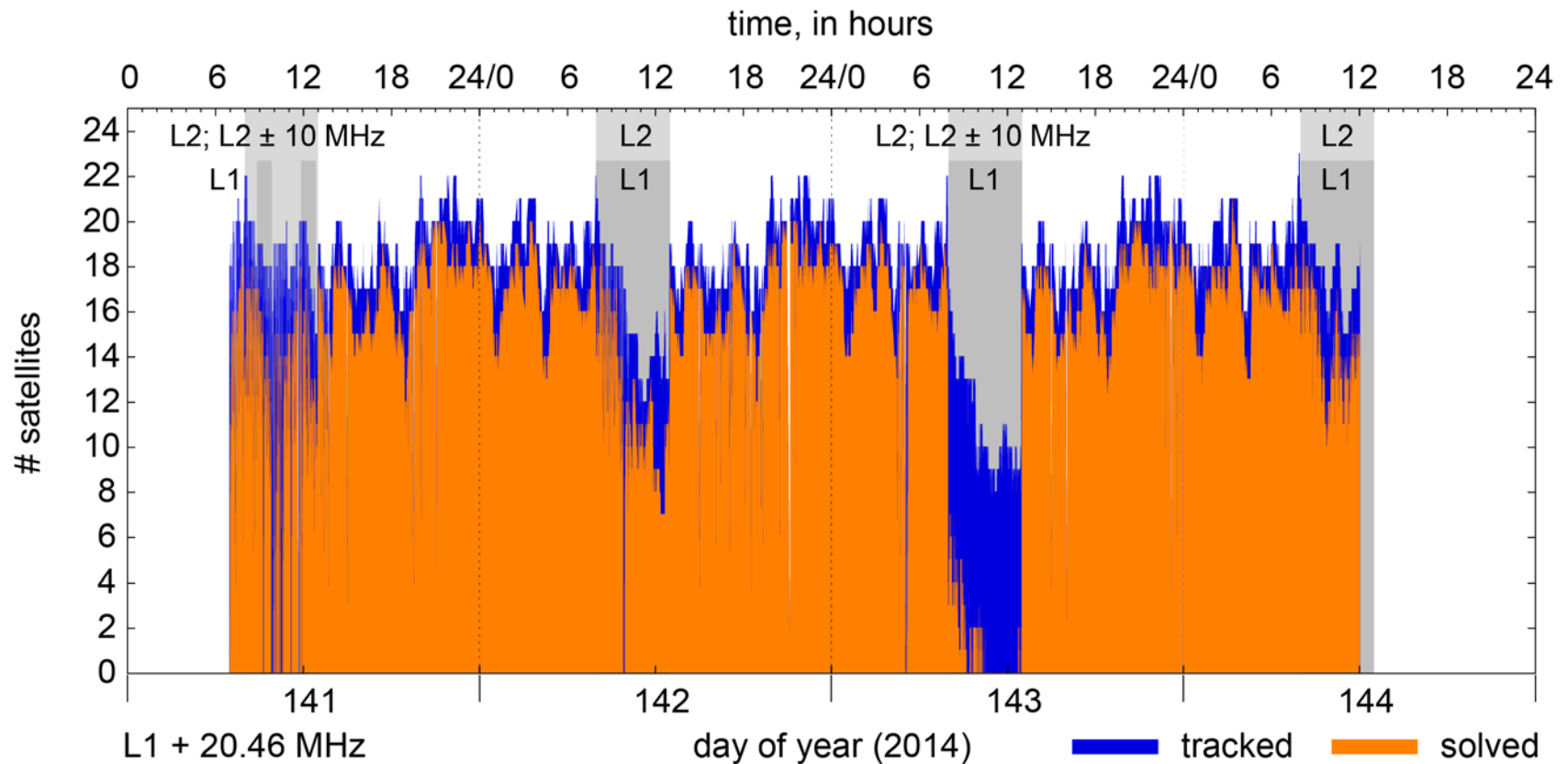
88%

78%

88%

KVM3

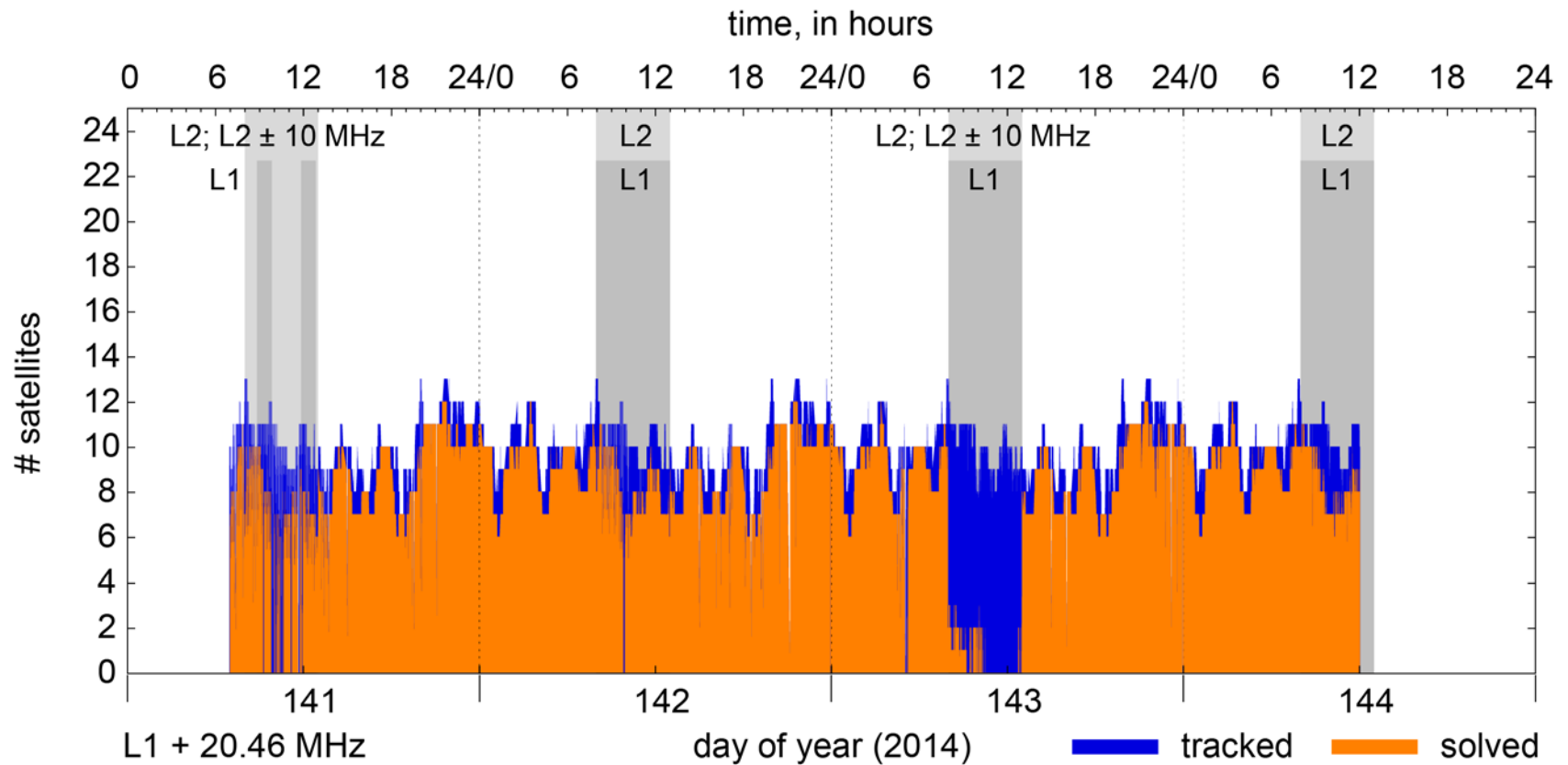
tracked vs. solved | GPS + GLONASS



NETWORK PROCESSOR STATUS #5

KVM3

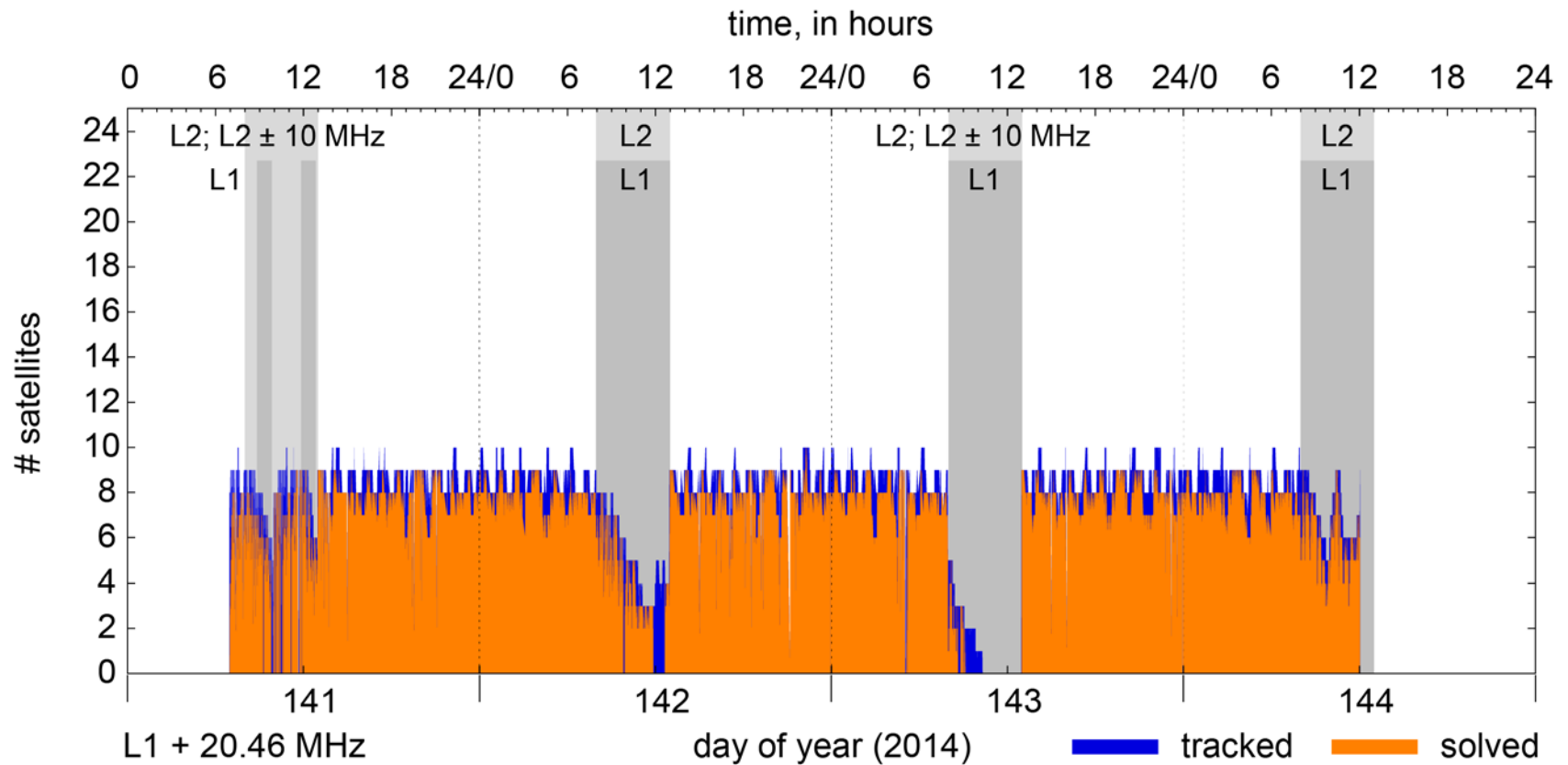
tracked vs. solved | GPS



NETWORK PROCESSOR STATUS #6

KVM3

tracked vs. solved | GLONASS



INTEGRITY MONITOR RTK-ENGINE

mean positioning integrity monitor (TPP RTKengine) | kvm3

time, in hours (UTC)

