NVIS Field Research in Spain
Science or Adventure?

dr. ing. B. A. Witvliet [wit fleet]

PE5B, MØIJQ

UNIVERSITY OF BATH

Radiocommunications Agency Netherlands

HamSCI meeting
NJIT, Newark, NJ, USA
23-24 February 2018

Introduction

Ben Witvliet [wit fleet]

Born in 1961 in Netherlands New Guinea
Father JZoCW, brother OZ1KGU, uncle PAoWDW

1973	NL4496 (SWL)
1981	PA3BXC
1982	3A/PA3BXC
1989	4X/PA3BXC
1993	5R8DS
1996	PA5BW
2016	PE5B
2017	MØIJQ

My first receiver

Otra 9R-4J vacuum tube receiver with BFO

Introduction

Ben Witvliet [wit fleet]

I have made my passion my work

Telecom industry

- Trans World Radio – Monte-Carlo, Monaco
- KPN Telecom – The Netherlands
- Radio Netherlands – Madagascar
- Netherlands Broadcasting Company

Applied research

- Radiocommunications Agency Netherlands 50%

Academic research

- University of Twente The Netherlands
- University of Bath United Kingdom 50%

The story

I will tell you the story of **curiosity-driven** research into the role of radio wave **polarization** in short-distance HF communication (**NVIS**).

Hidden messages:

☺ *Prepare well, and you will find amazing things!*

☺ *Science is adventure!*

Just an ordinary day at the office (2008)

Radiocommunications Agency Netherlands

UNIVERSITY OF BATH

But then it happened …

PAØSIM:

> "*I receive local stations on 3.5 MHz with Right-Hand Circular Polarization, and Jugoslav stations with Left-Hand Circular Polarization, and …* "

We: "*You … what !?*"

?

real / not real

But then it happened …

We decided to visit him. And we stayed very late..!!

Wow!

2x Alford loop

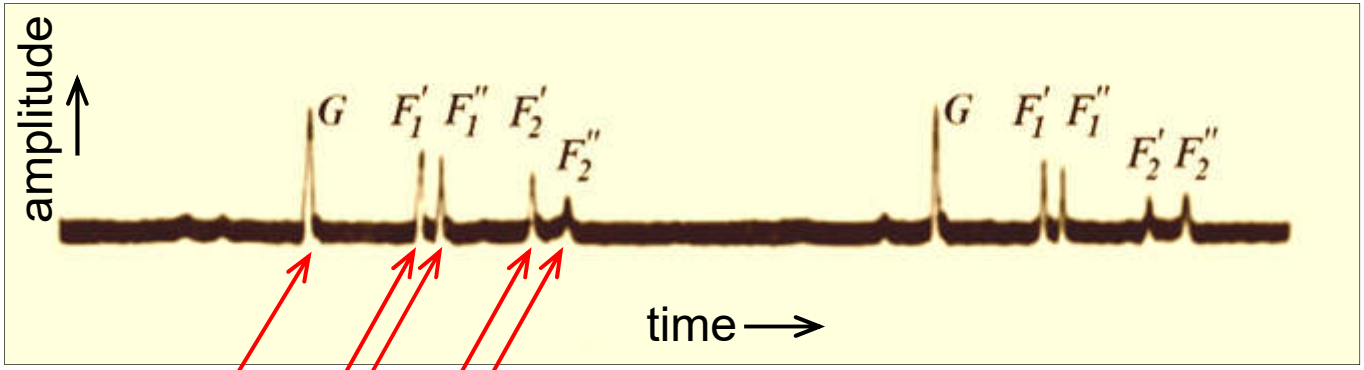
2x modified FT1000MP

http://www.pa0sim.nl/

UNIVERSITY OF BATH

This is where the journey starts …

We re-discovered the work of Appleton (1933) …



ground wave

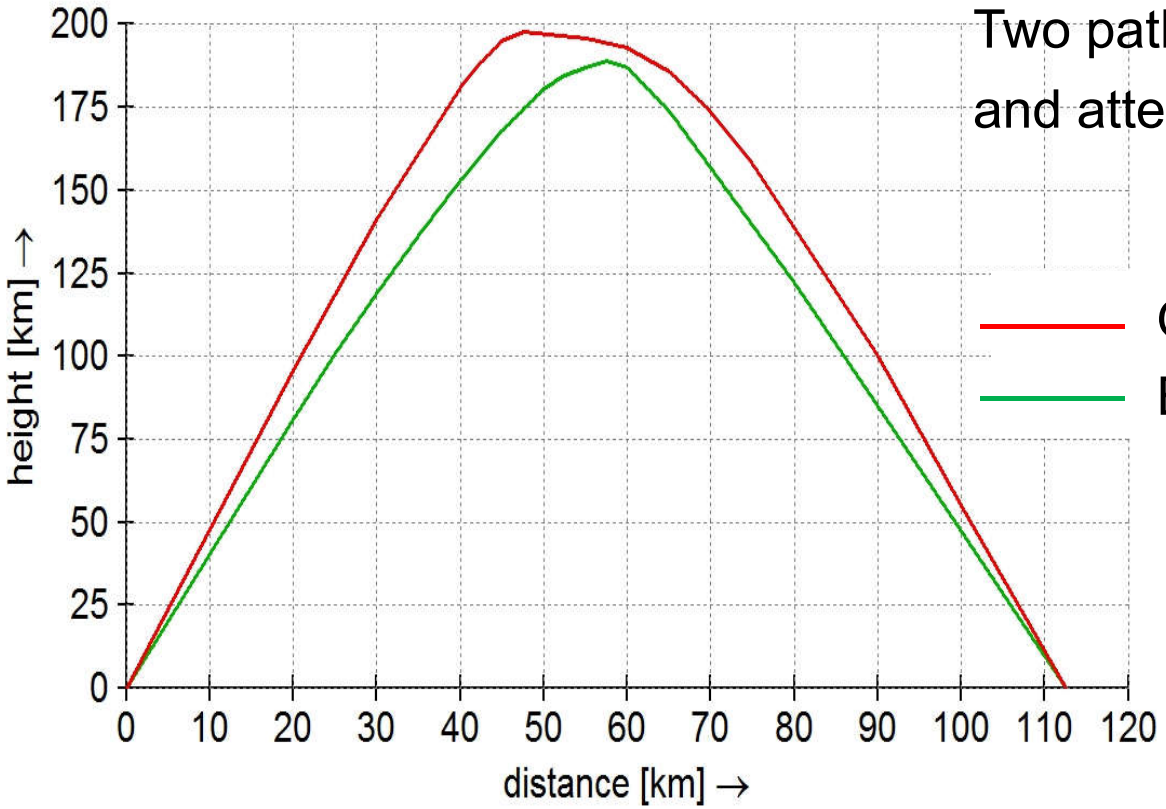
circularly polarized, with clockwise rotation (RHCP)

circularly polarized, with counter-clockwise (LHCP)

Appleton, E. V., and G. Builder (1933), "The Ionosphere as a Doubly-Refracting Medium," Proc. Phys. Soc., 45, (2), pp. 208-220.

This is where the journey starts …

… and combined it with ionospheric simulations



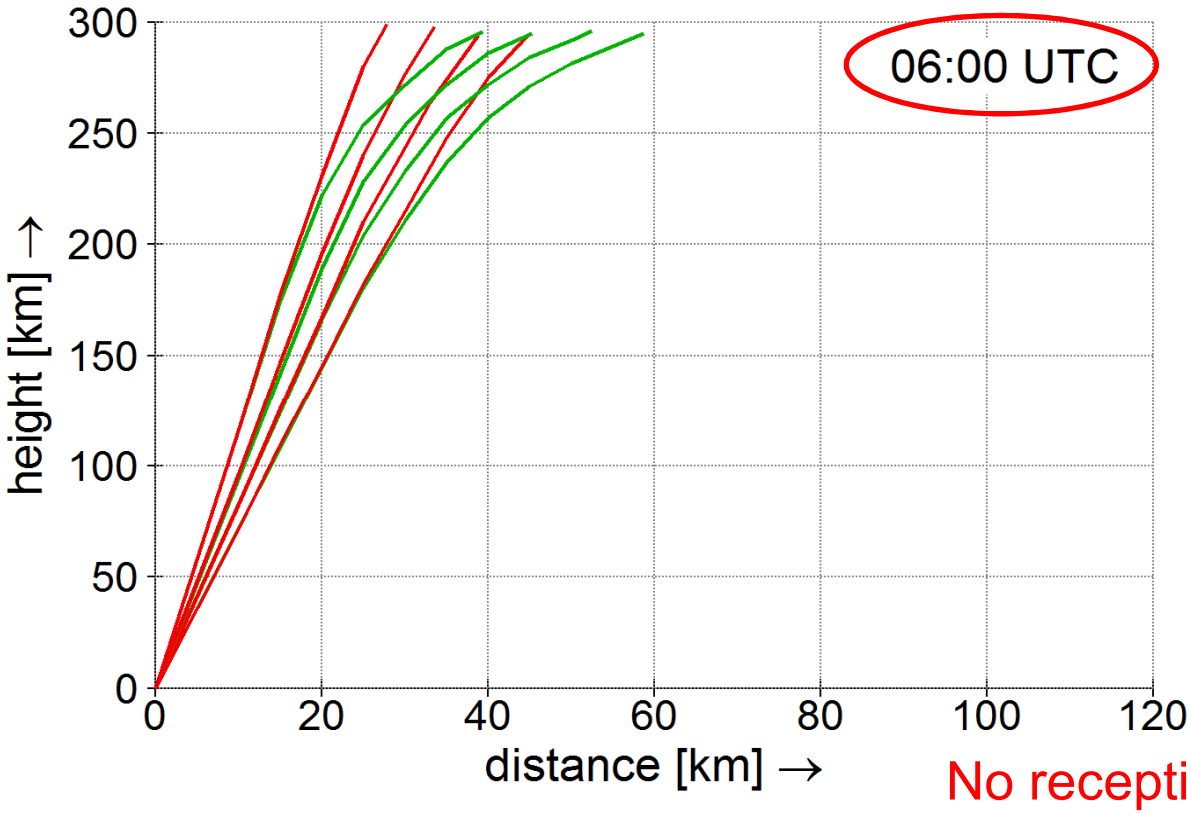
Two paths with different delay and attenuation (varying)

Ordinary wave

Extraordinary wave

This is where the journey starts …

We followed the changing propagation over the day



9 March 2014

Ray-tracing simulations
The Netherlands
7 MHz, SSN 79

Ordinary wave
Extraordinary wave

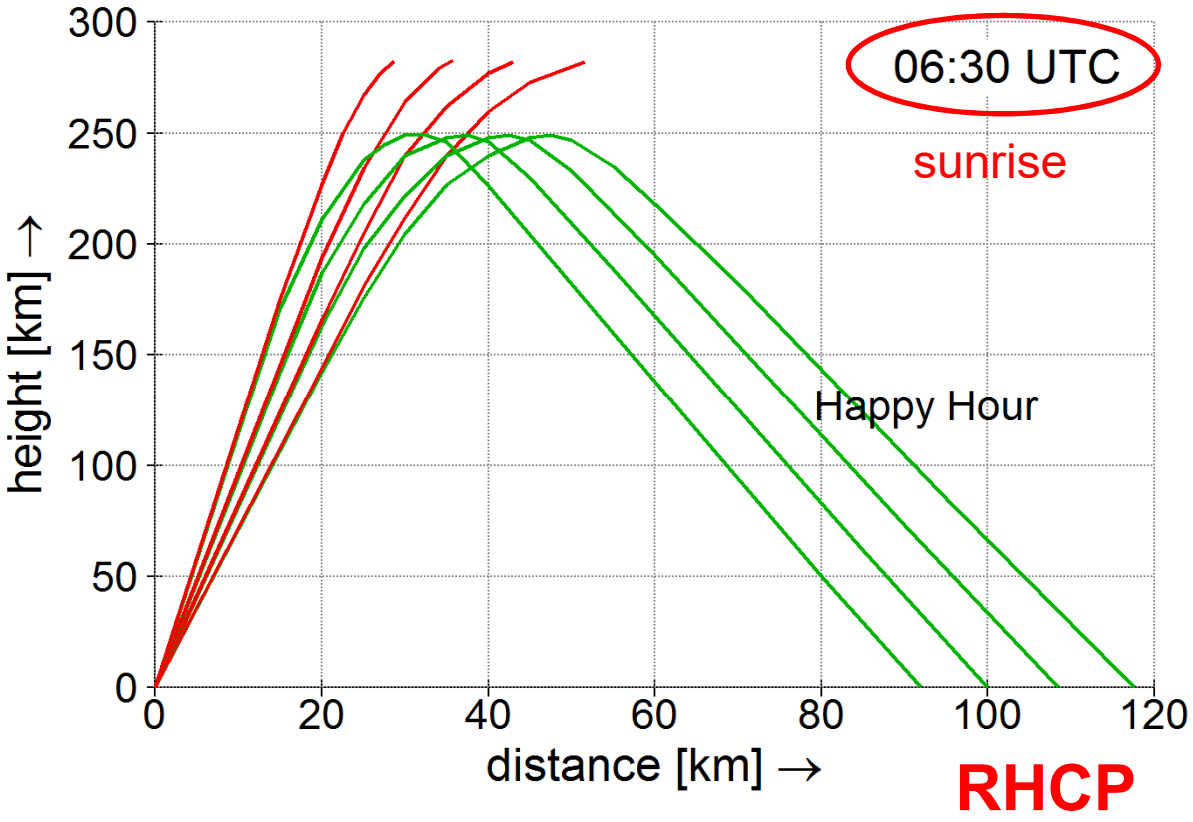
No reception

Witvliet, Ben A., et al. "Measuring the Isolation of the Circularly Polarized Characteristic Waves in NVIS Propagation [Measurements Corner]." IEEE Antennas and Propagation Magazine 57.3 (2015): 120-145.

UNIVERSITY OF BATH

This is where the journey starts …

We followed the changing propagation over the day



9 March 2014

Ray-tracing simulations
The Netherlands
7 MHz, SSN 79

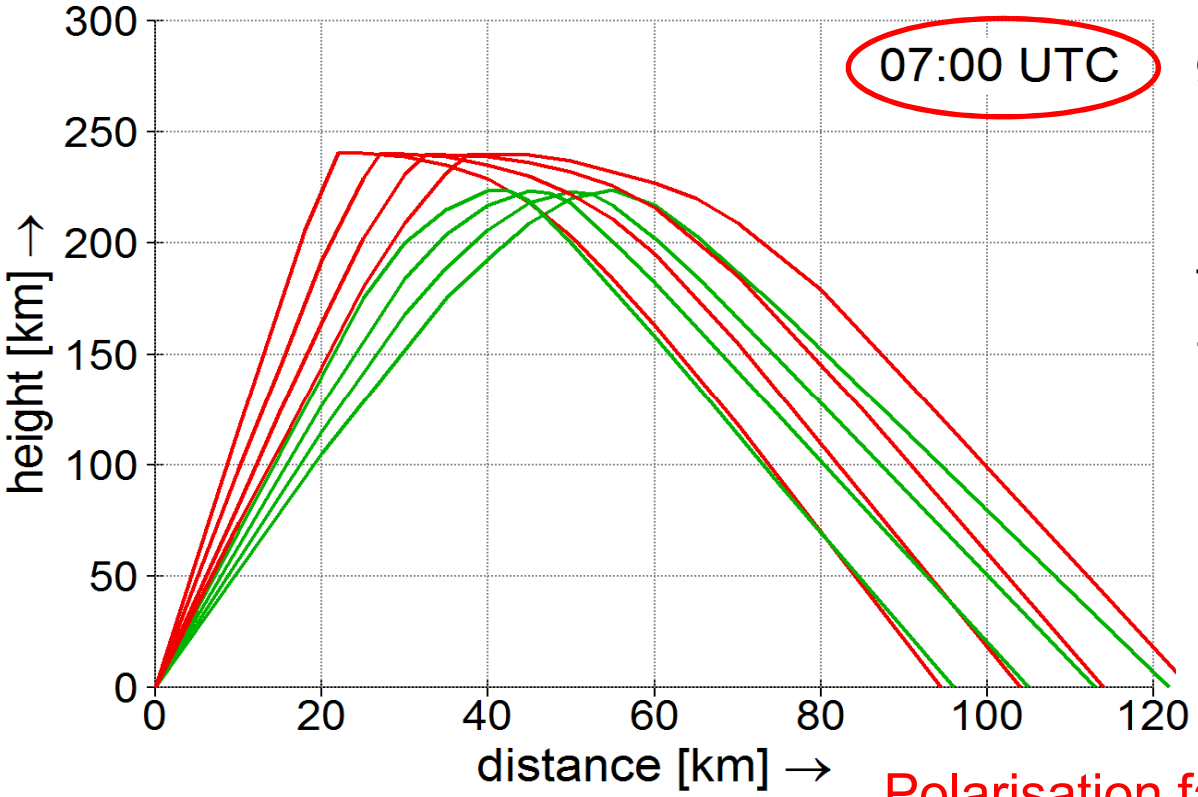
Ordinary wave
Extraordinary wave

Witvliet, Ben A., et al. "Measuring the Isolation of the Circularly Polarized Characteristic Waves in NVIS Propagation [Measurements Corner]." IEEE Antennas and Propagation Magazine 57.3 (2015): 120-145.

UNIVERSITY OF BATH

This is where the journey starts …

We followed the changing propagation over the day



9 March 2014

Ray-tracing simulations
The Netherlands
7 MHz, SSN 79

Ordinary wave
Extraordinary wave

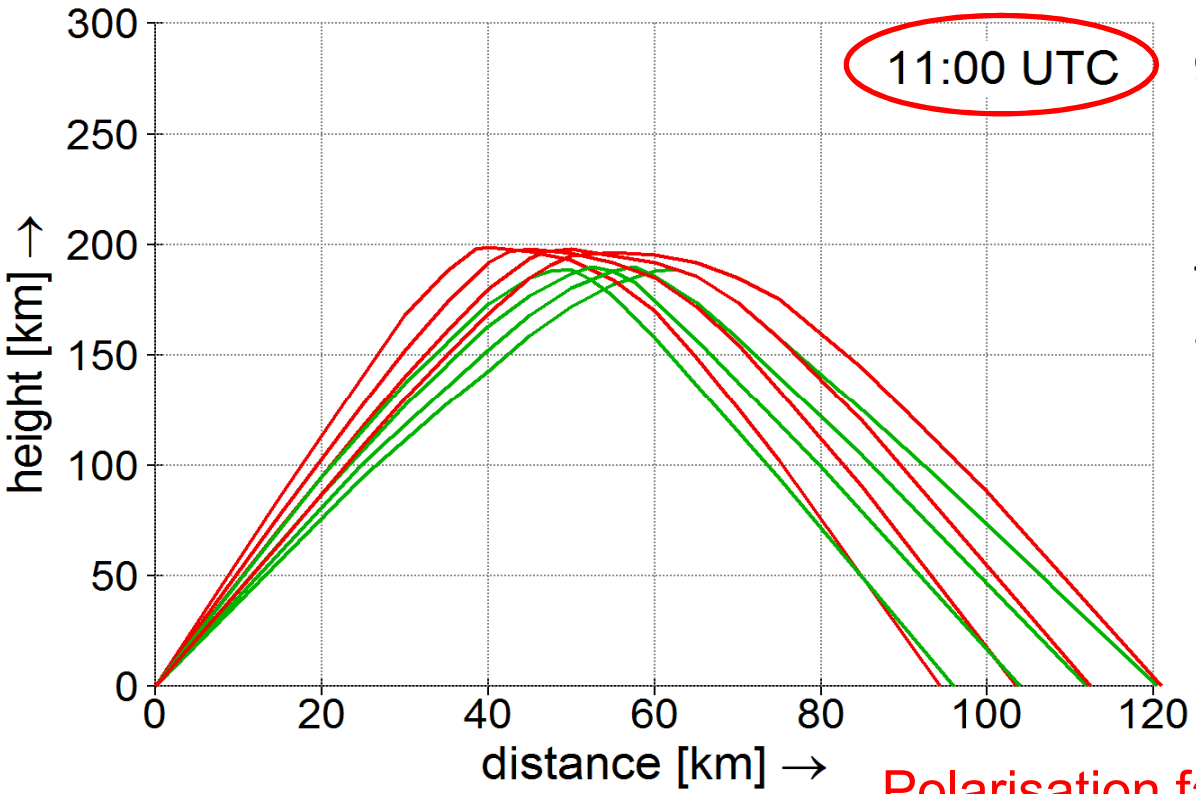
Polarisation fading

Witvliet, Ben A., et al. "Measuring the Isolation of the Circularly Polarized Characteristic Waves in NVIS Propagation [Measurements Corner]." IEEE Antennas and Propagation Magazine 57.3 (2015): 120-145.

UNIVERSITY OF BATH

This is where the journey starts …

We followed the changing propagation over the day



9 March 2014

Ray-tracing simulations
The Netherlands
7 MHz, SSN 79

Ordinary wave
Extraordinary wave

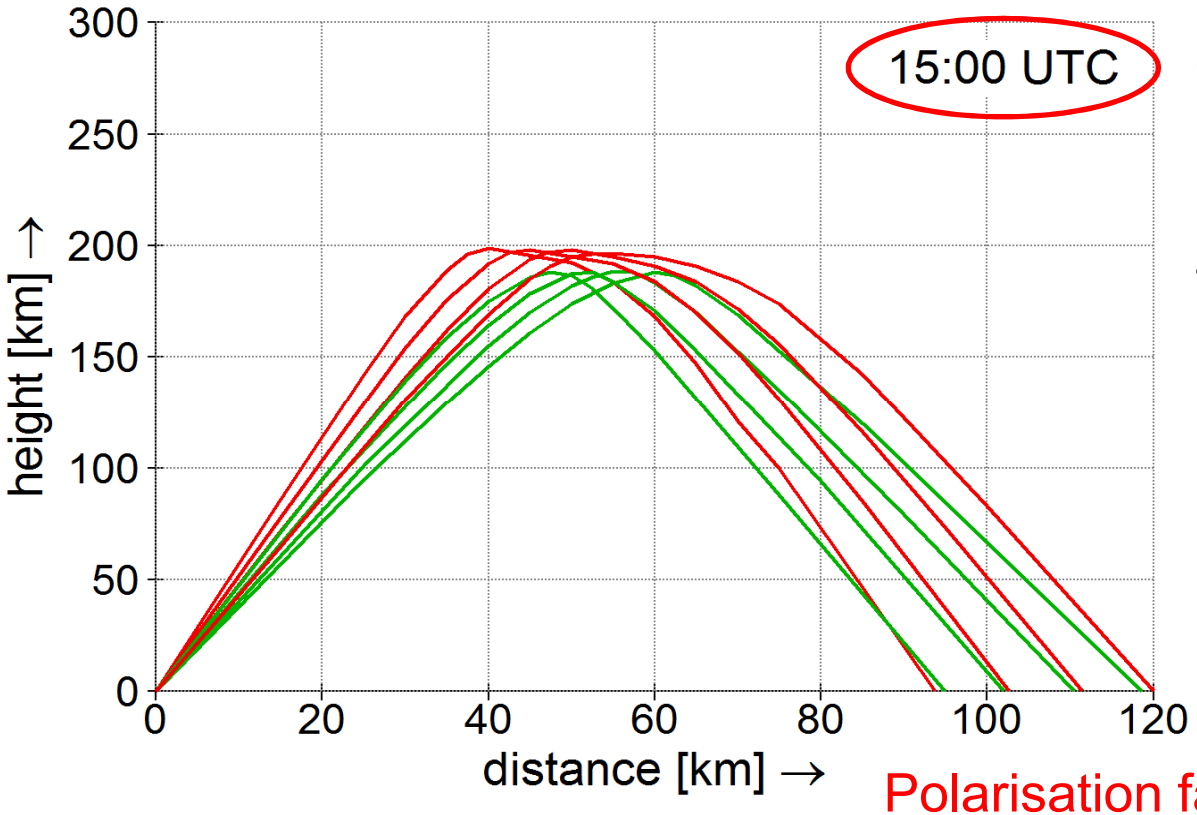
Polarisation fading

Witvliet, Ben A., et al. "Measuring the Isolation of the Circularly Polarized Characteristic Waves in NVIS Propagation [Measurements Corner]." IEEE Antennas and Propagation Magazine 57.3 (2015): 120-145.

UNIVERSITY OF BATH

This is where the journey starts …

We followed the changing propagation over the day



9 March 2014

Ray-tracing simulations
The Netherlands
7 MHz, SSN 79

Ordinary wave
Extraordinary wave

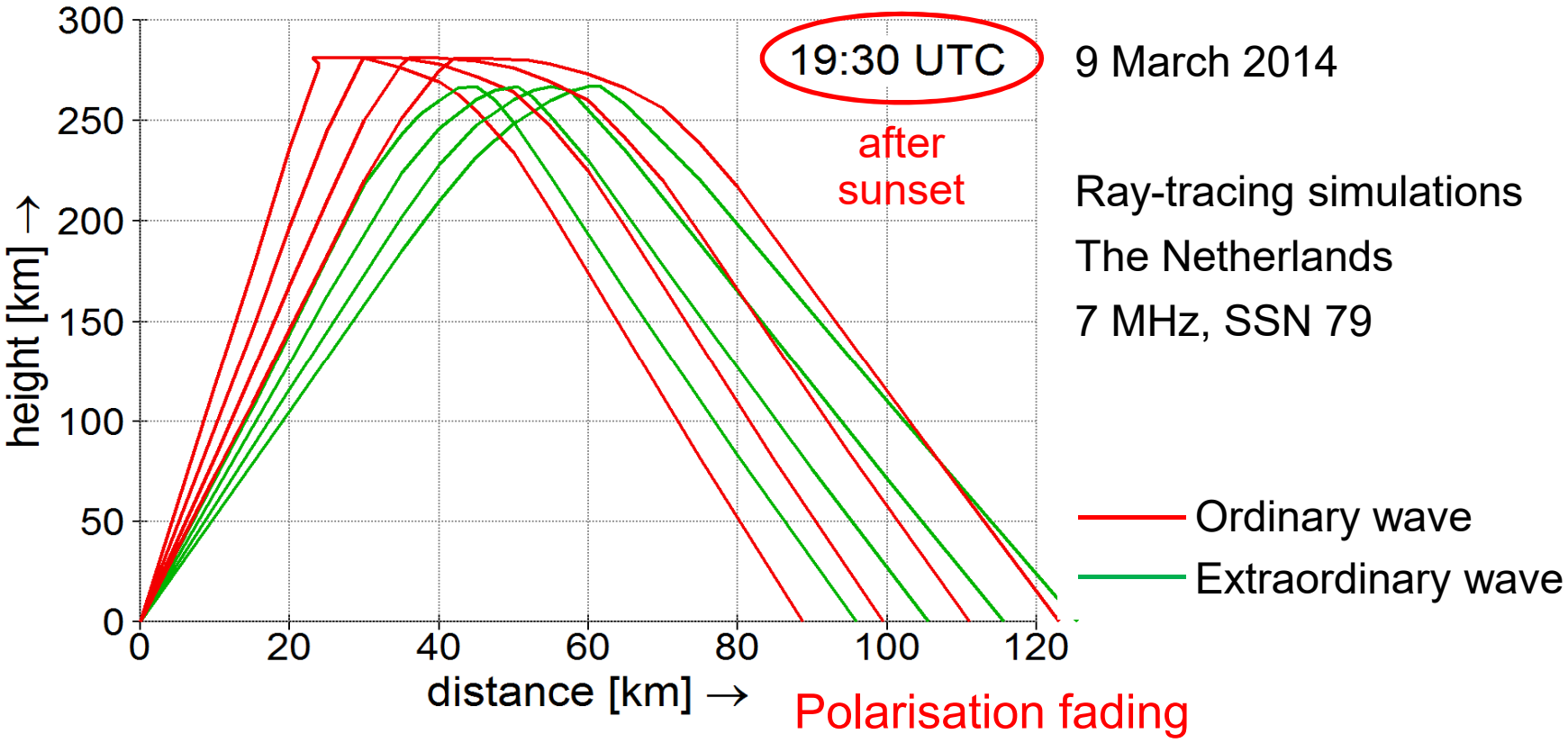
Polarisation fading

Witvliet, Ben A., et al. "Measuring the Isolation of the Circularly Polarized Characteristic Waves in NVIS Propagation [Measurements Corner]." IEEE Antennas and Propagation Magazine 57.3 (2015): 120-145.

UNIVERSITY OF BATH

This is where the journey starts …

We followed the changing propagation over the day

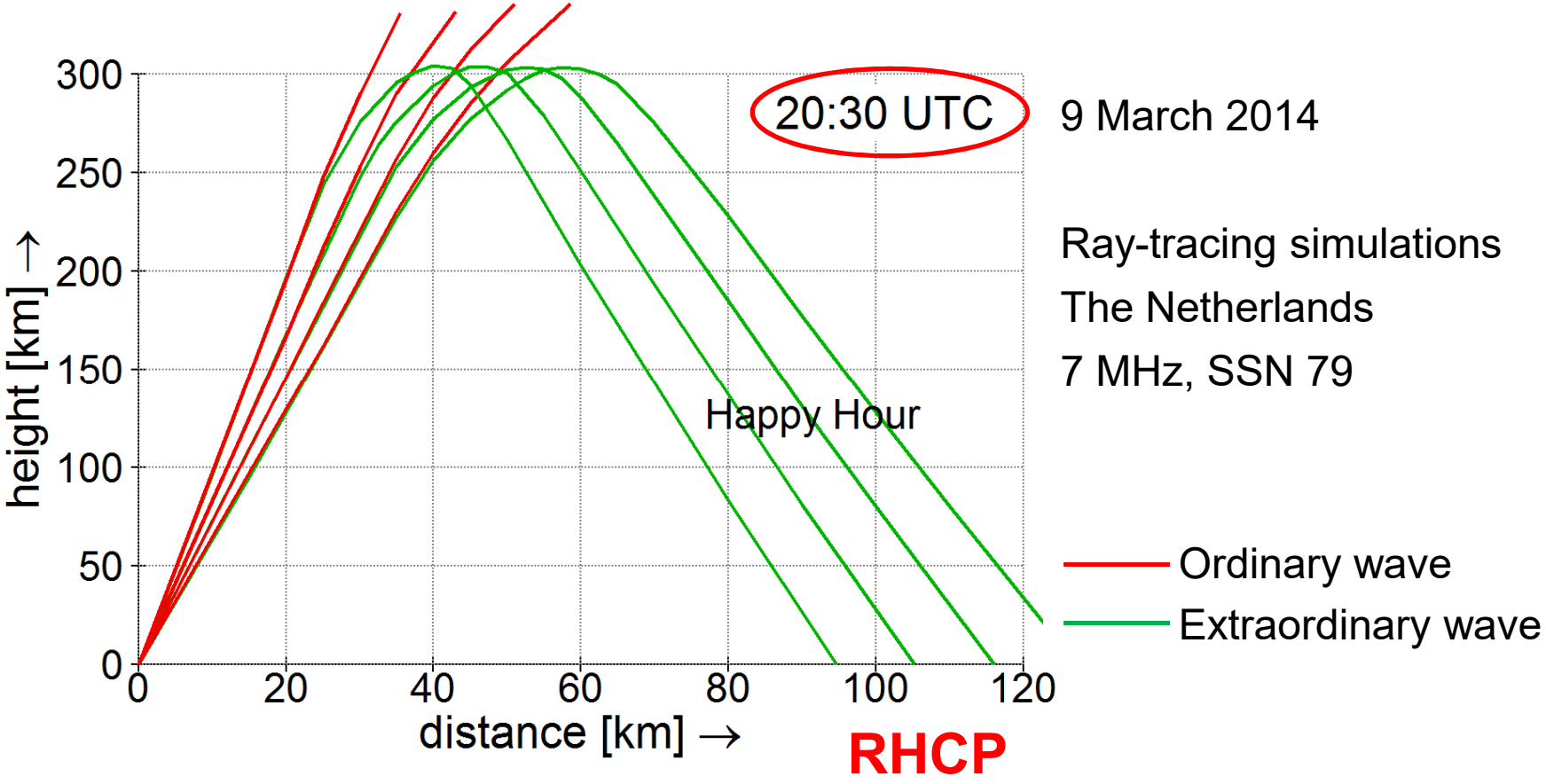


Witvliet, Ben A., et al. "Measuring the Isolation of the Circularly Polarized Characteristic Waves in NVIS Propagation [Measurements Corner]." IEEE Antennas and Propagation Magazine 57.3 (2015): 120-145.

UNIVERSITY OF BATH

This is where the journey starts …

We followed the changing propagation over the day



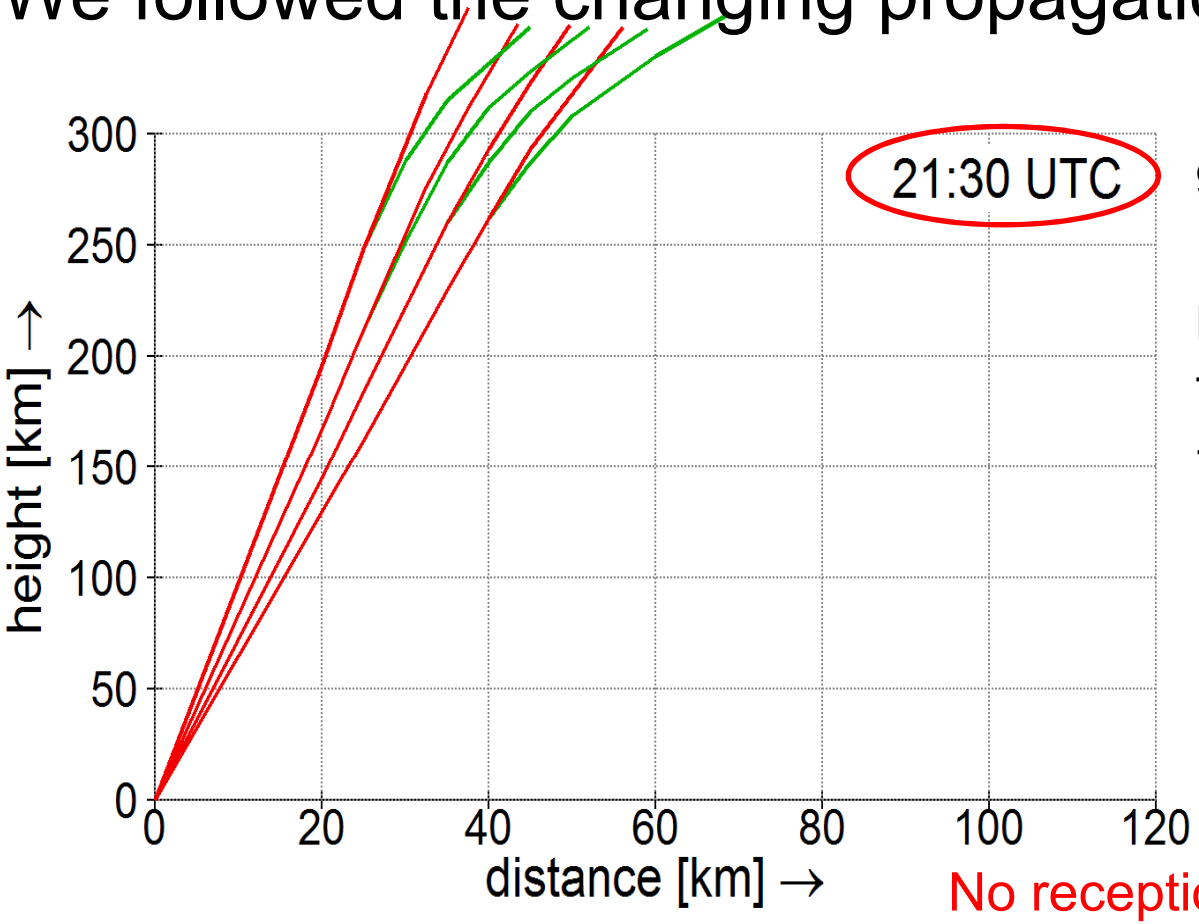
Witvliet, Ben A., et al. "Measuring the Isolation of the Circularly Polarized Characteristic Waves in NVIS Propagation [Measurements Corner]." IEEE Antennas and Propagation Magazine 57.3 (2015): 120-145.

UNIVERSITY OF BATH

This is where the journey starts …

0:05

We followed the changing propagation over the day



9 March 2014

Ray-tracing simulations
The Netherlands
7 MHz, SSN 79

Ordinary wave
Extraordinary wave

Witvliet, Ben A., et al. "Measuring the Isolation of the Circularly Polarized Characteristic Waves in NVIS Propagation [Measurements Corner]." IEEE Antennas and Propagation Magazine 57.3 (2015): 120-145.

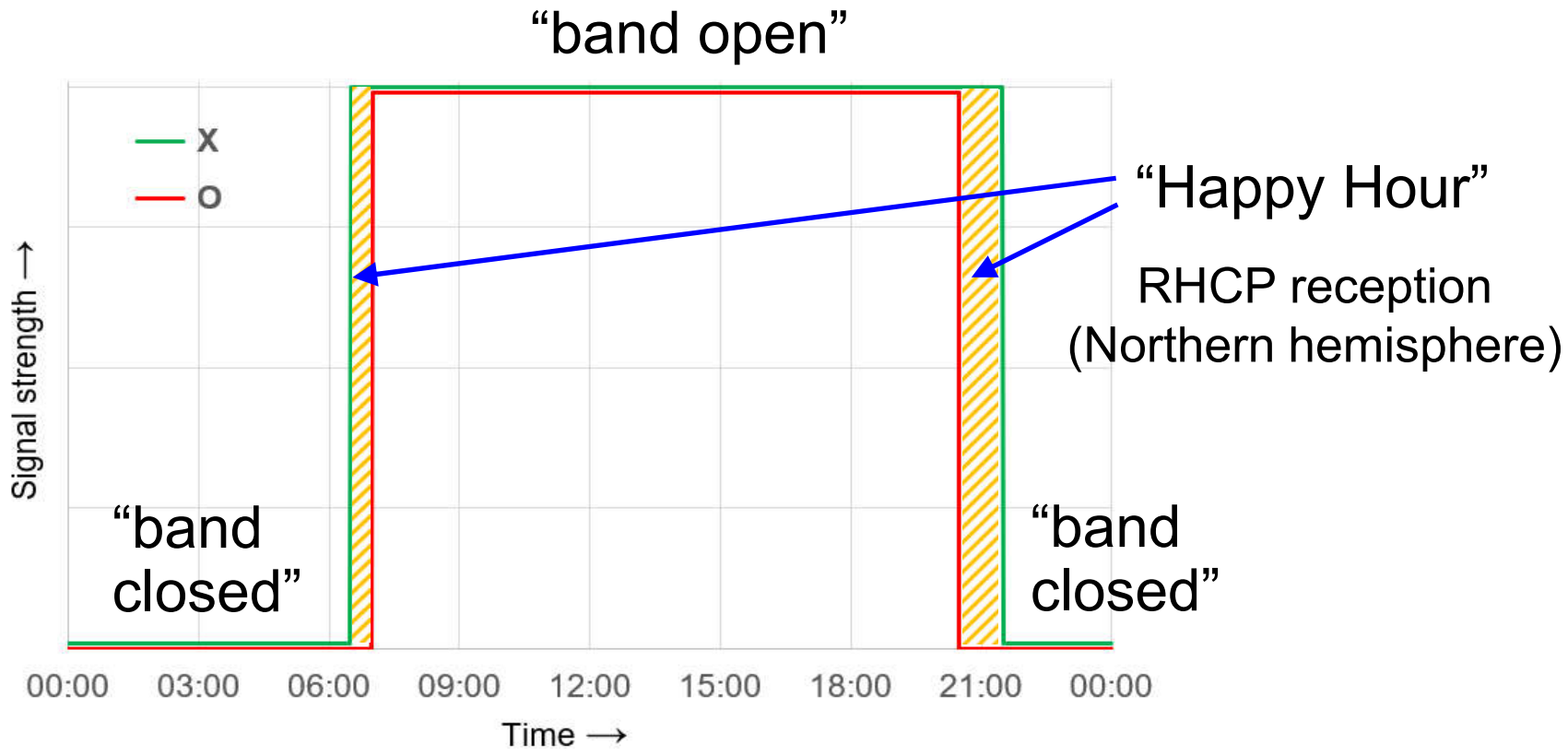
UNIVERSITY OF BATH

This is where the journey starts …

… and divined the location of the Pot of Gold

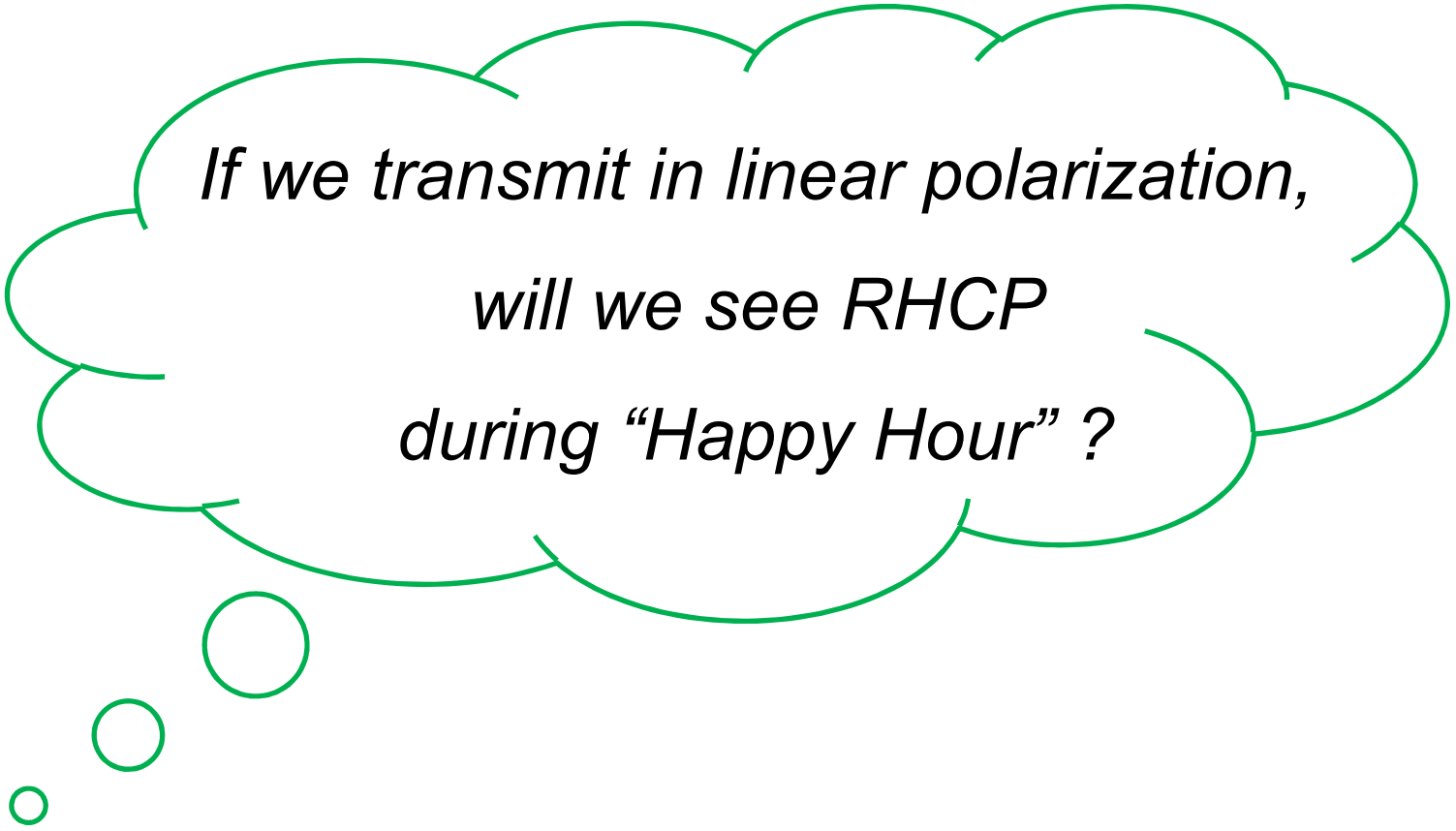
This is where the journey starts …

… and divined the location of the Pot of Gold



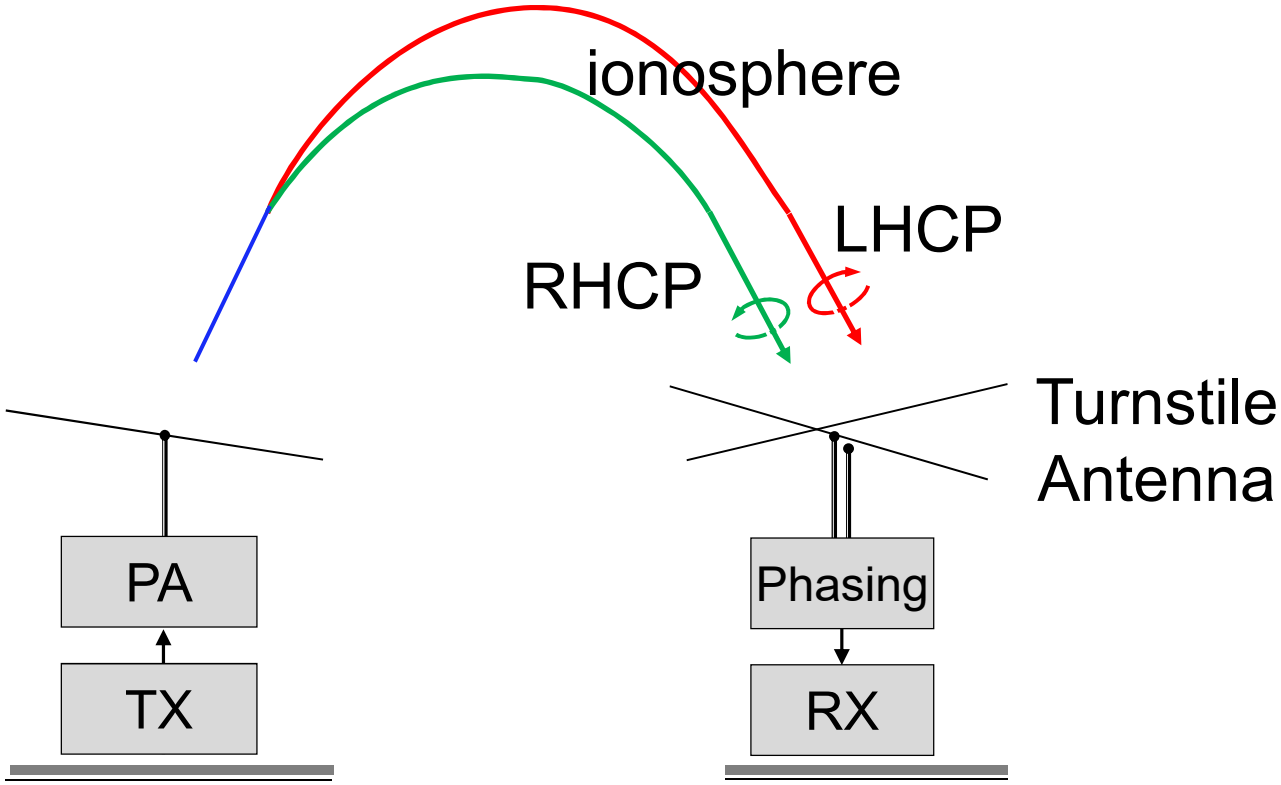
This is where the journey starts …

This led to a curiosity-driven experiment …



A very adventurous journey (first leg)

This led to a curiosity-driven experiment …



Witvliet, Ben A., et al. "The importance of circular polarization for diversity reception and MIMO in NVIS propagation." Antennas and Propagation (EuCAP), 2014 8th European Conference on. IEEE, 2014.

A very adventurous journey (first leg)

… using equipment that was “just lying around” ☺

5.39 MHz Turnstile Antenna

Rohde & Schwarz FSMR26

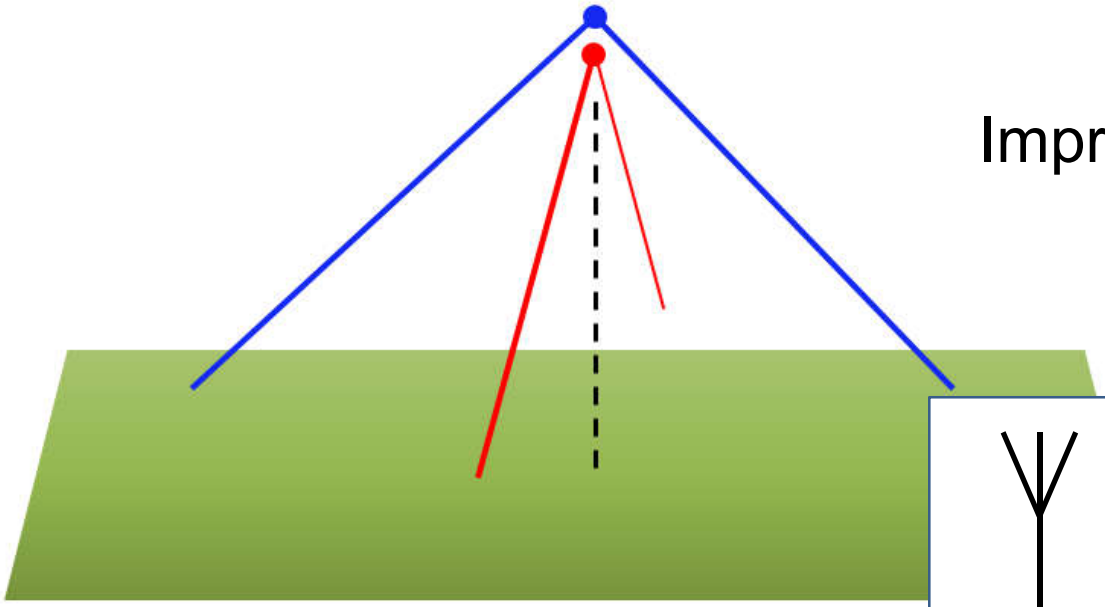
$100,000

Witvliet, Ben A., et al. "The importance of circular polarization for diversity reception and MIMO in NVIS propagation." Antennas and Propagation (EuCAP), 2014 8th European Conference on. IEEE, 2014.

UNIVERSITY OF BATH

A very adventurous journey (first leg)

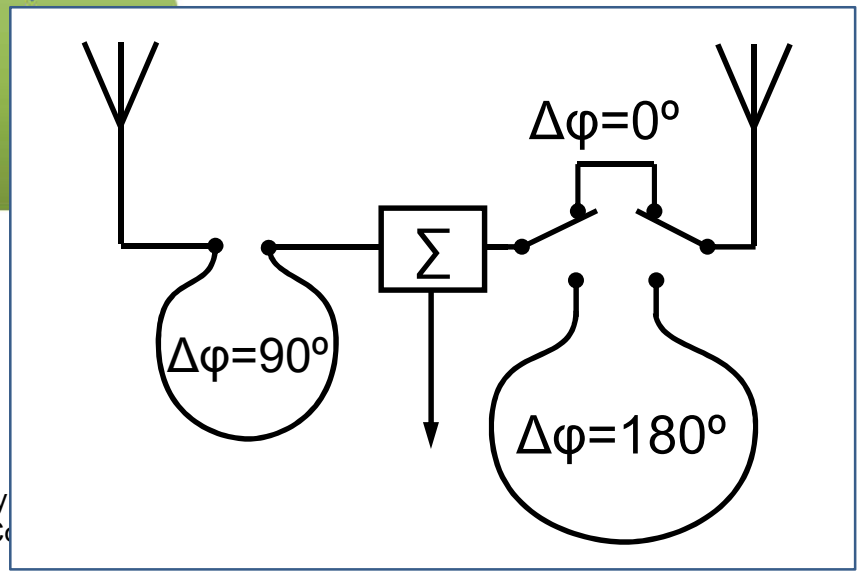
… using equipment that was “just lying around” ☺



Improvised phasing network

$\Delta\varphi = +90^o$ or -90^o

(switched)



Witvliet, Ben A., et al. "The importance of circular polarization for diversity
propagation." Antennas and Propagation (EuCAP), 2014 8th European C

A very adventurous journey (first leg)

… using equipment that was “just lying around” ☺

Scrap-heap challenge

PAØA transmitter on 5.39 MHz

P = 800 Watts, ΔP < 0.1 dB

f = 5.39 MHz, Δf < 5 Hz

1 minute on / 1 minute off

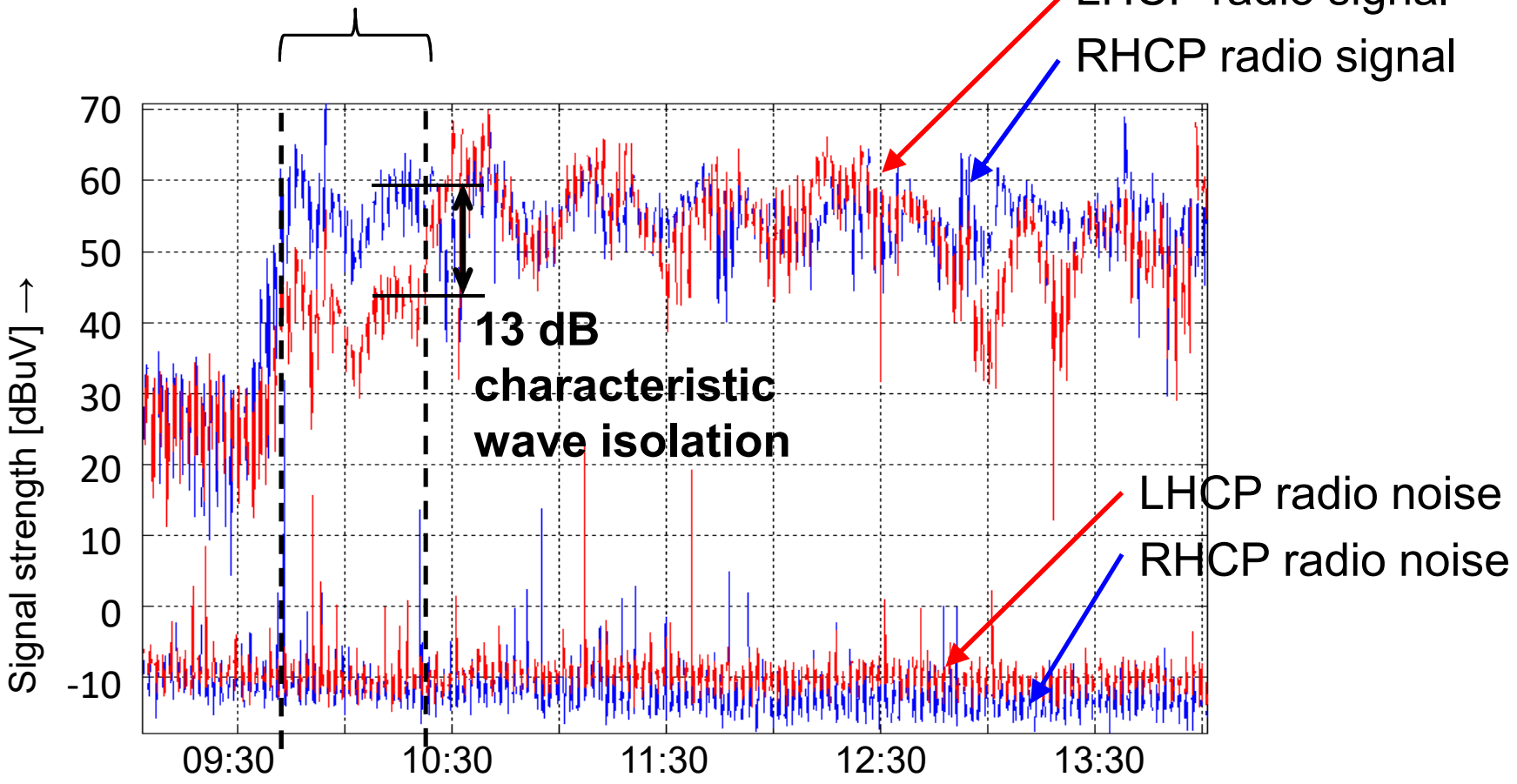
DCF controlled timing

Witvliet, Ben A., et al. "The importance of circular polarization for diversity reception and MIMO in NVIS propagation." Antennas and Propagation (EuCAP), 2014 8th European Conference on. IEEE, 2014.

UNIVERSITY OF BATH

Results of the first leg

First “Happy Hour” observations!

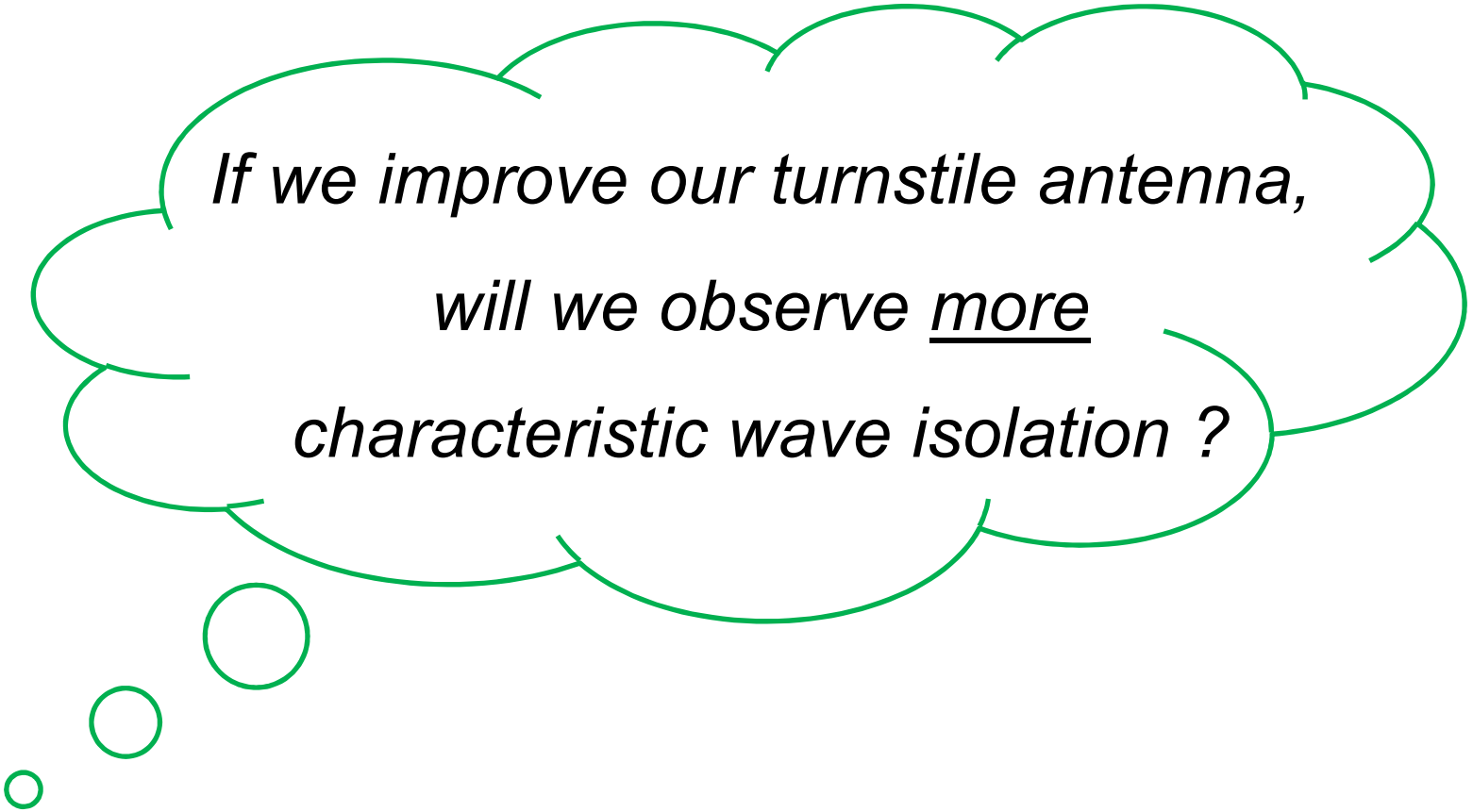


Witvliet, Ben A., et al. "The importance of circular polarization for diversity reception and MIMO in NVIS propagation." Antennas and Propagation (EuCAP), 2014 8th European Conference on. IEEE, 2014.

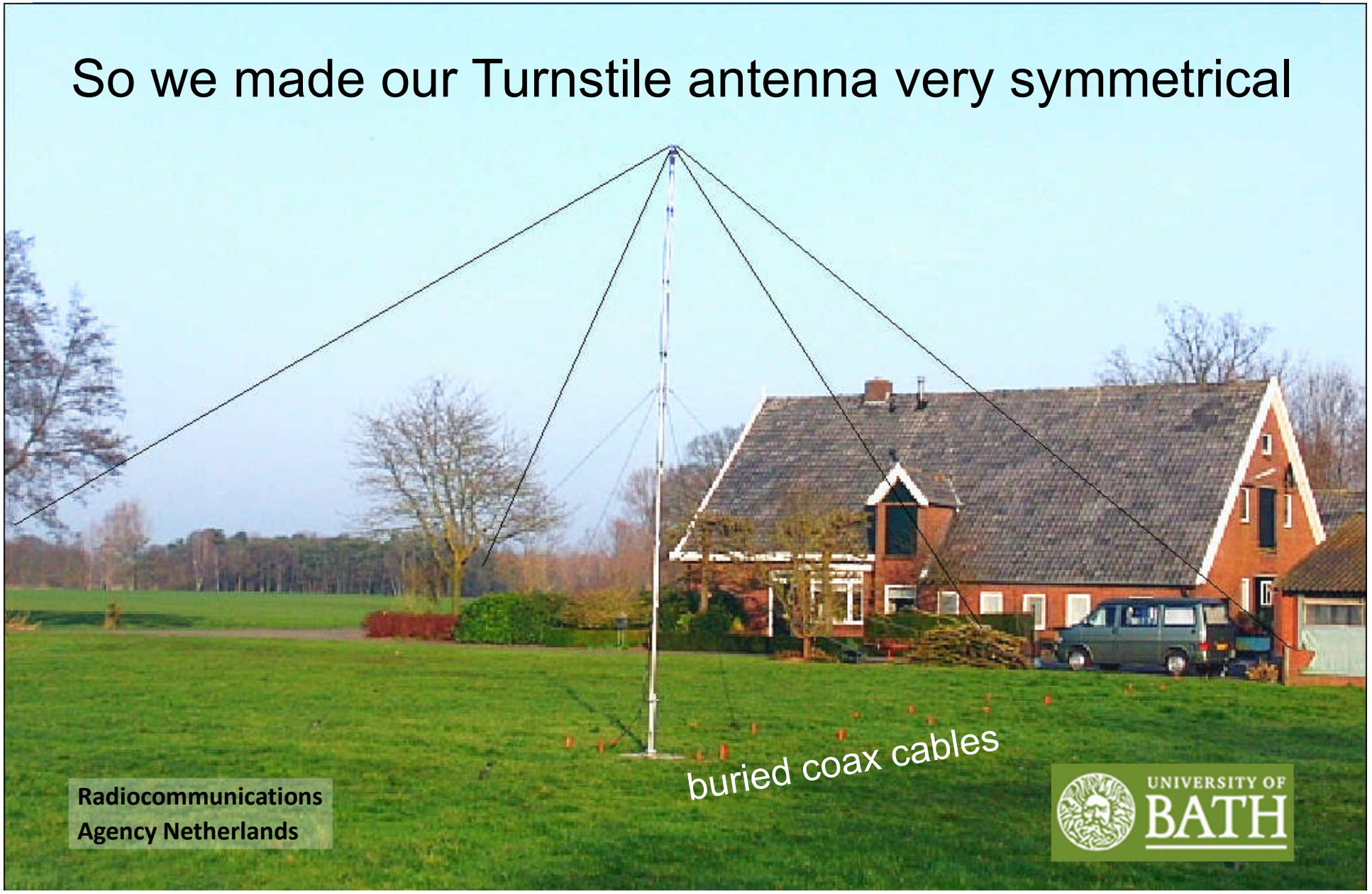
UNIVERSITY OF BATH

Results of the first leg

Arrived at the horizon, a new one that beckons …

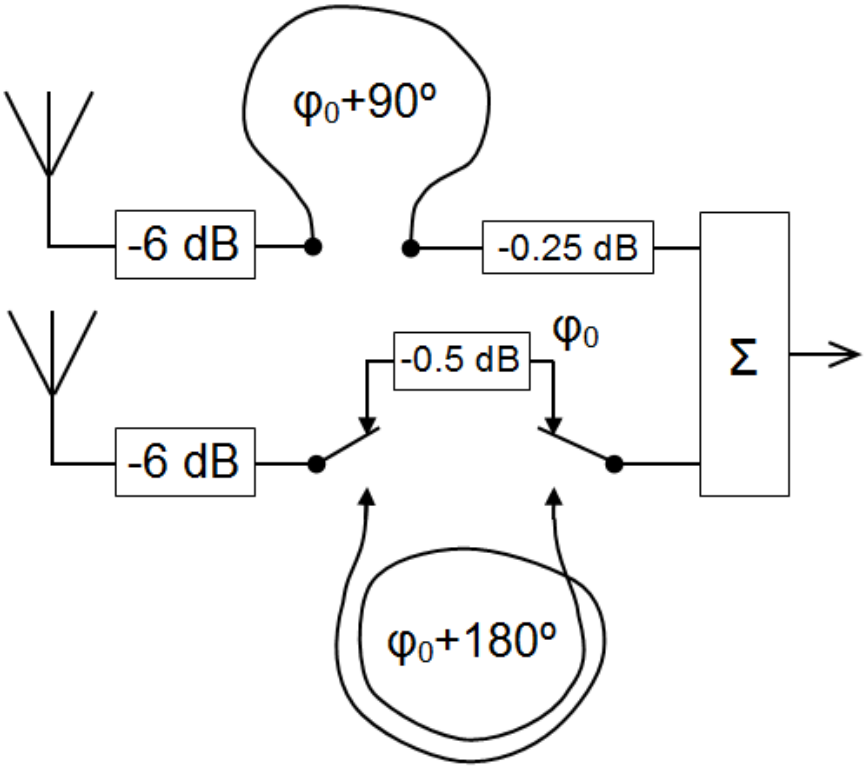


A very adventurous journey (second leg)

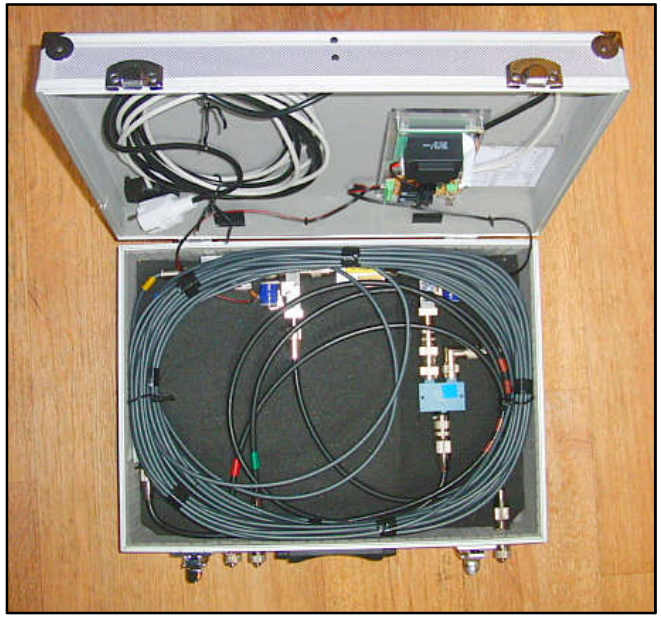


A very adventurous journey (second leg)

… perfected the phasing network …



$\Delta\varphi = 0.1°, \ \Delta P < 0.05$ dB

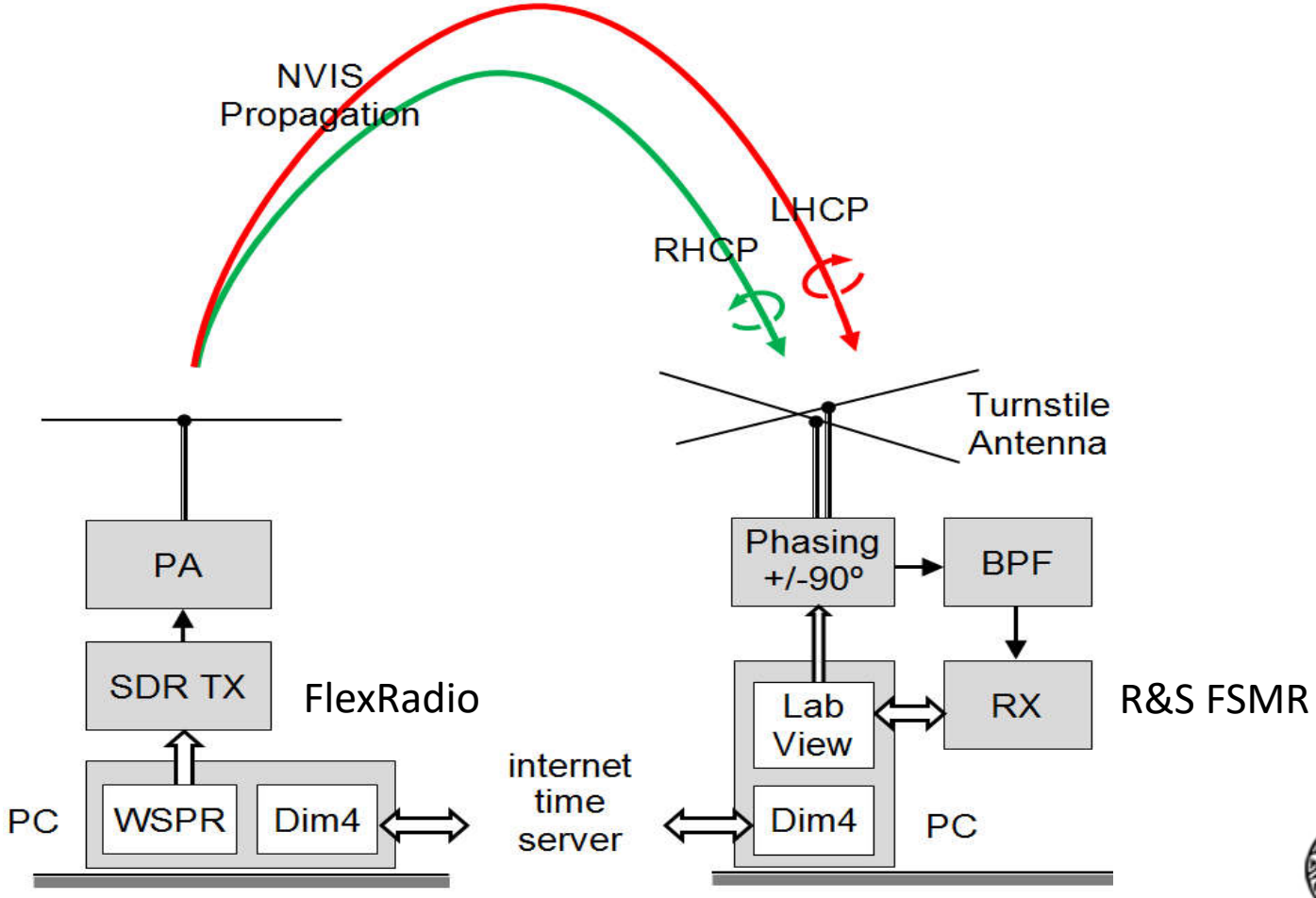


Witvliet, Ben A., et al. "Measuring the Isolation of the Circularly Polarized Characteristic Waves in NVIS Propagation [Measurements Corner]." IEEE Antennas and Propagation Magazine 57.3 (2015): 120-145.

UNIVERSITY OF BATH

A very adventurous journey (second leg)

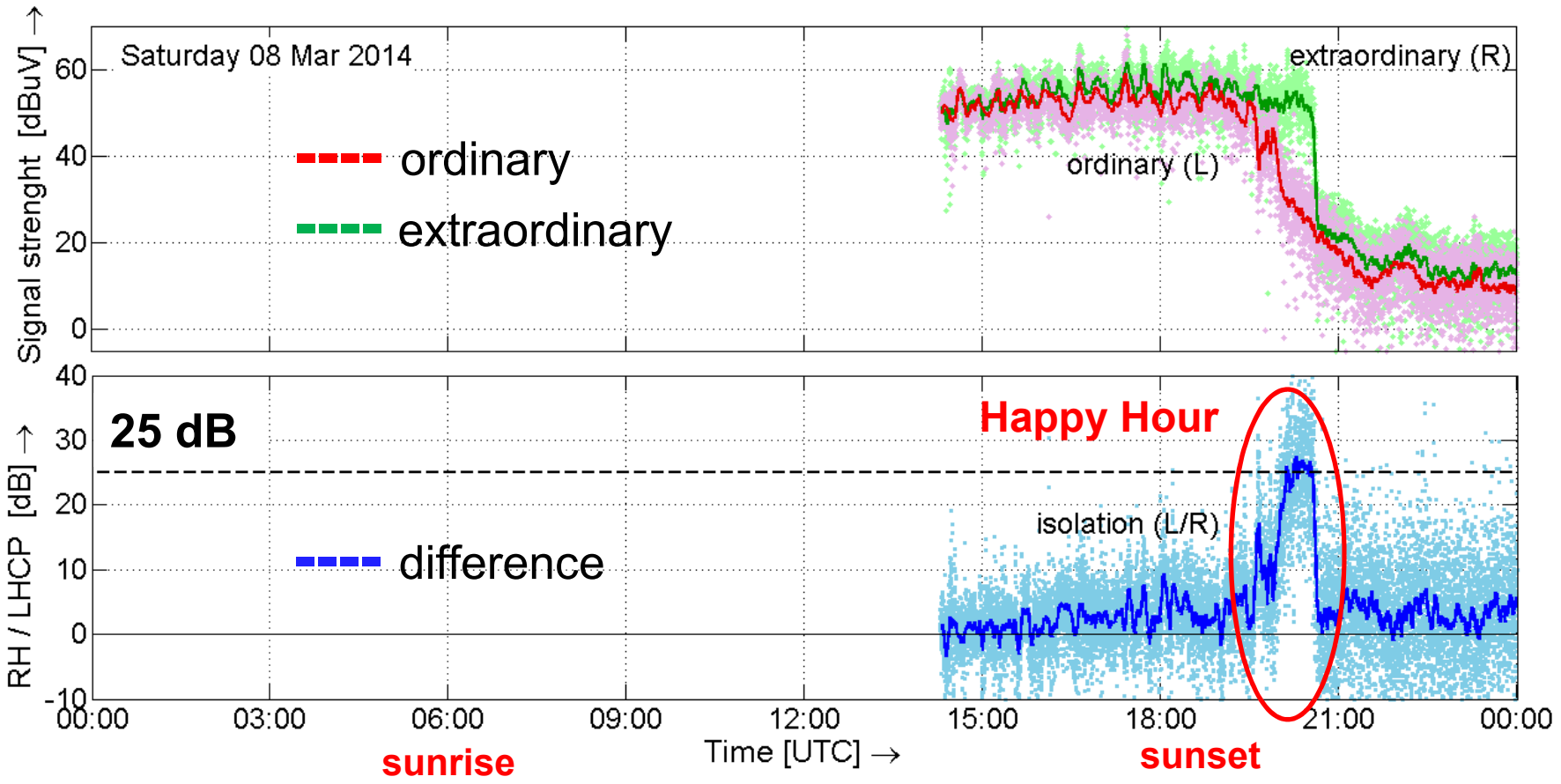
… and increased the measurement speed 30x



UNIVERSITY OF BATH

Results of the second leg

Now we see 25 dB characteristic wave isolation!

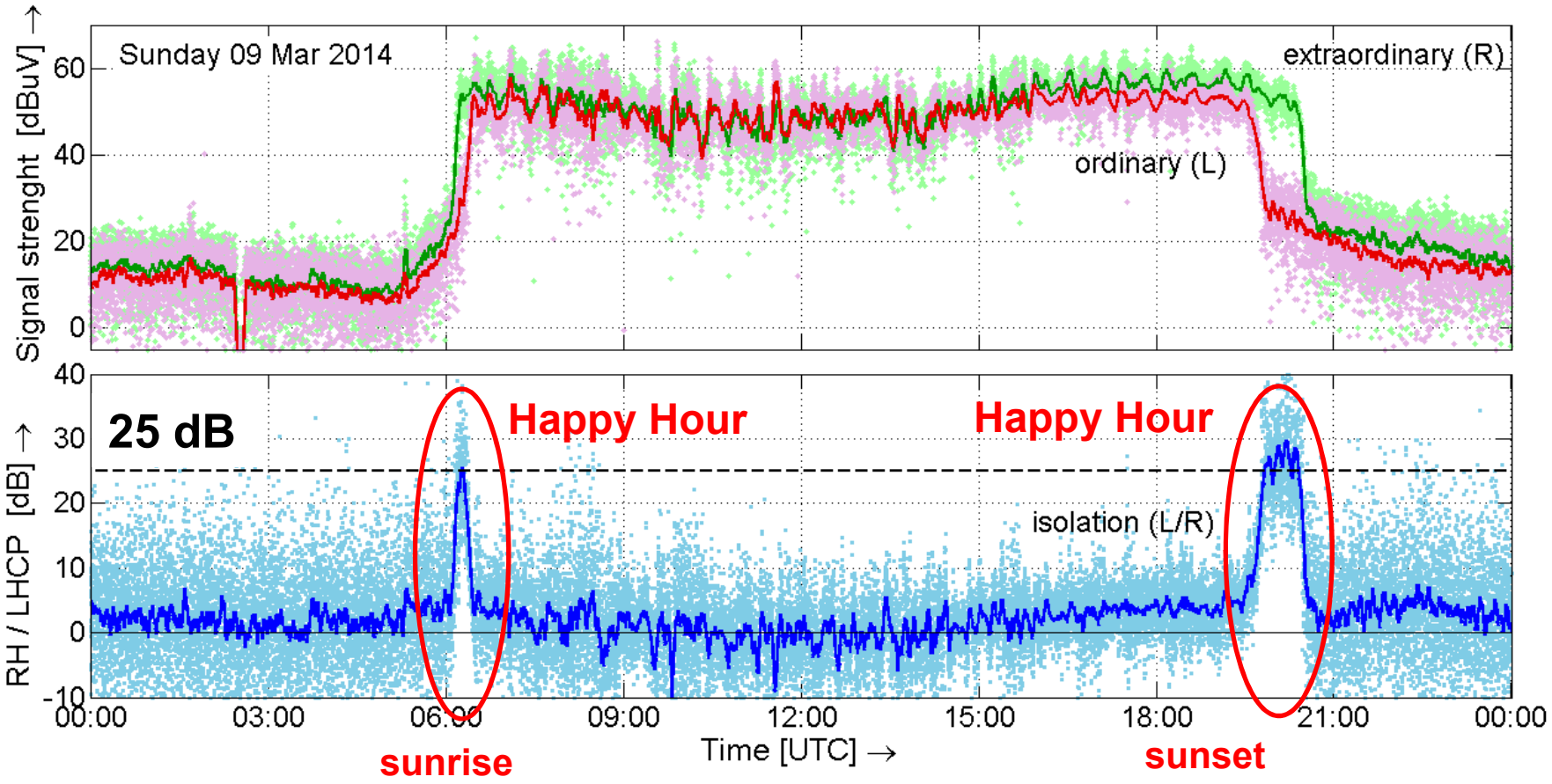


Radiocommunications Agency Netherlands

UNIVERSITY OF BATH

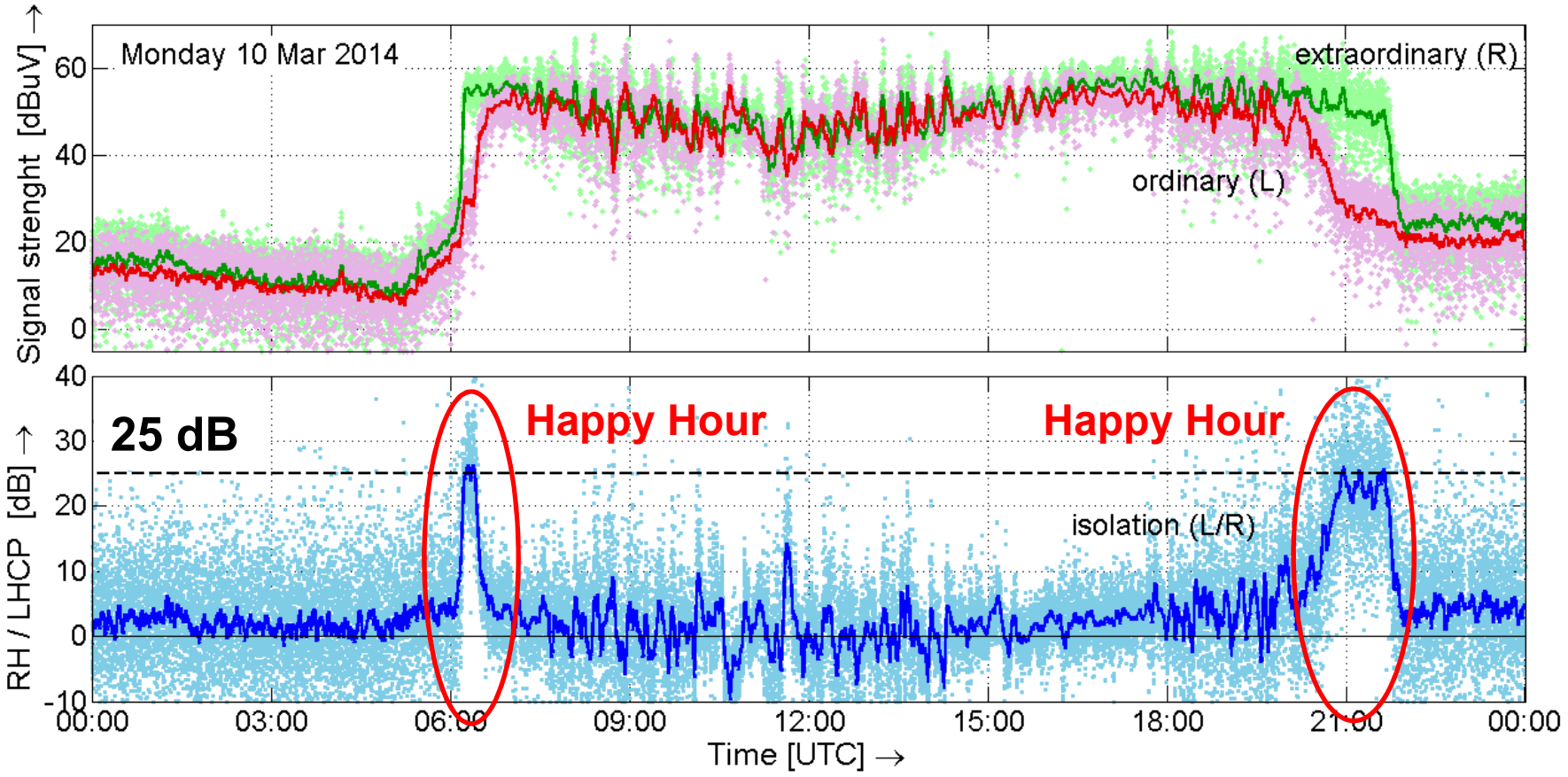
Results of the second leg

Now we see 25 dB characteristic wave isolation!



Results of the second leg

Now we see 25 dB characteristic wave isolation!



Witvliet, Ben A., et al. "Measuring the Isolation of the Circularly Polarized Characteristic Waves in NVIS Propagation [Measurements Corner]." IEEE Antennas and Propagation Magazine 57.3 (2015): 120-145.

UNIVERSITY OF BATH

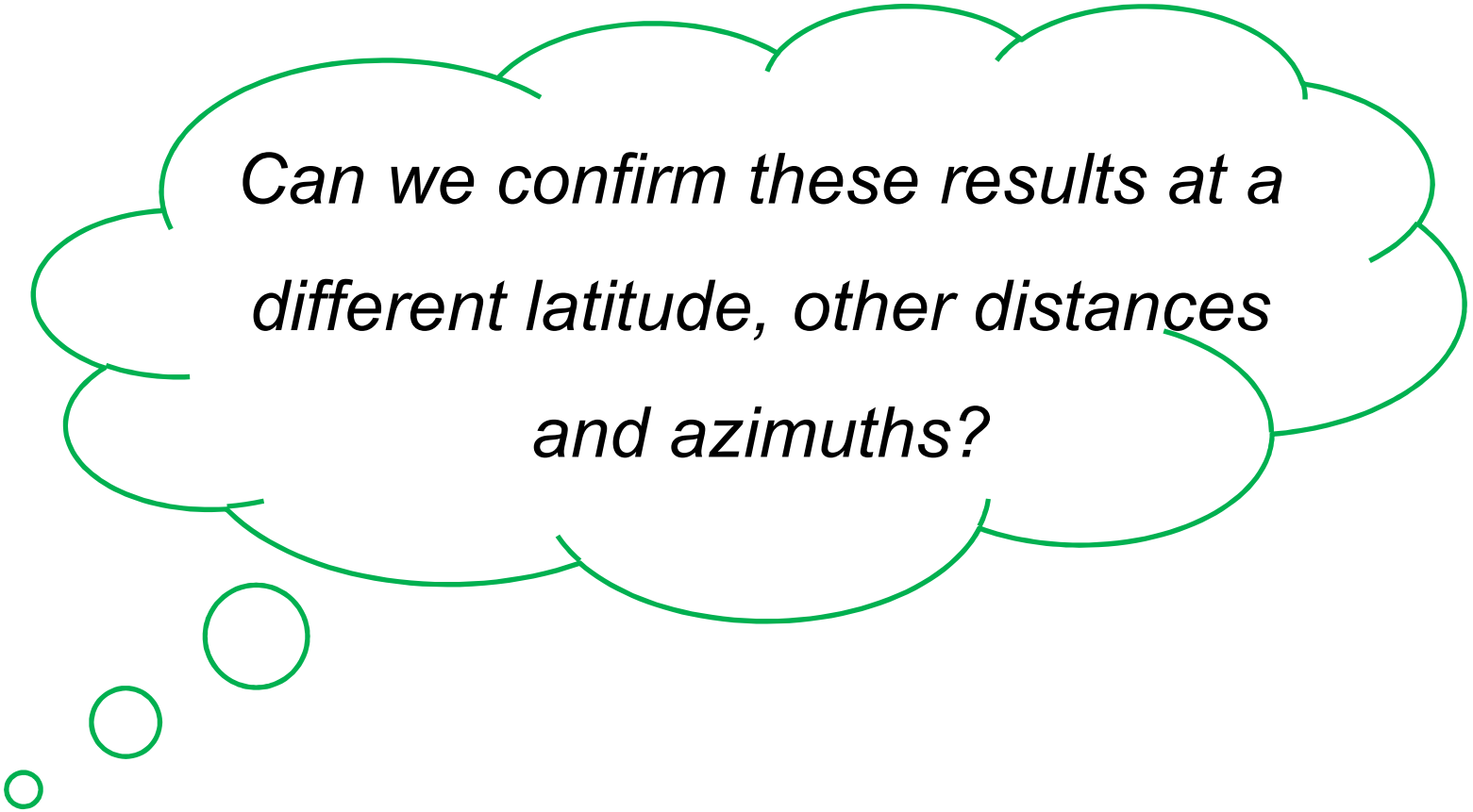
Results of the second leg

All our measurements were on 1 path at 53˚ North.

UNIVERSITY OF BATH

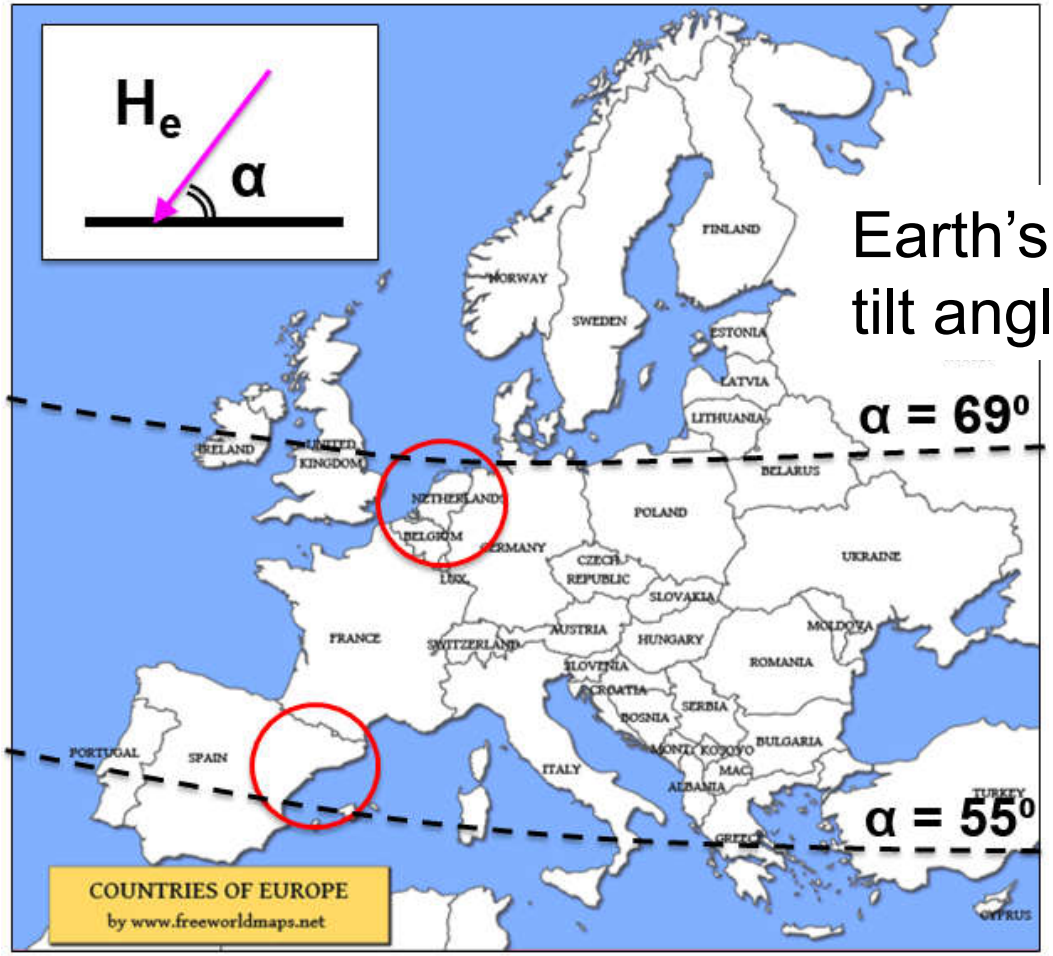
Results of the second leg

So that made us wonder:



A very adventurous journey (third leg)

What if we'd change latitude … ?



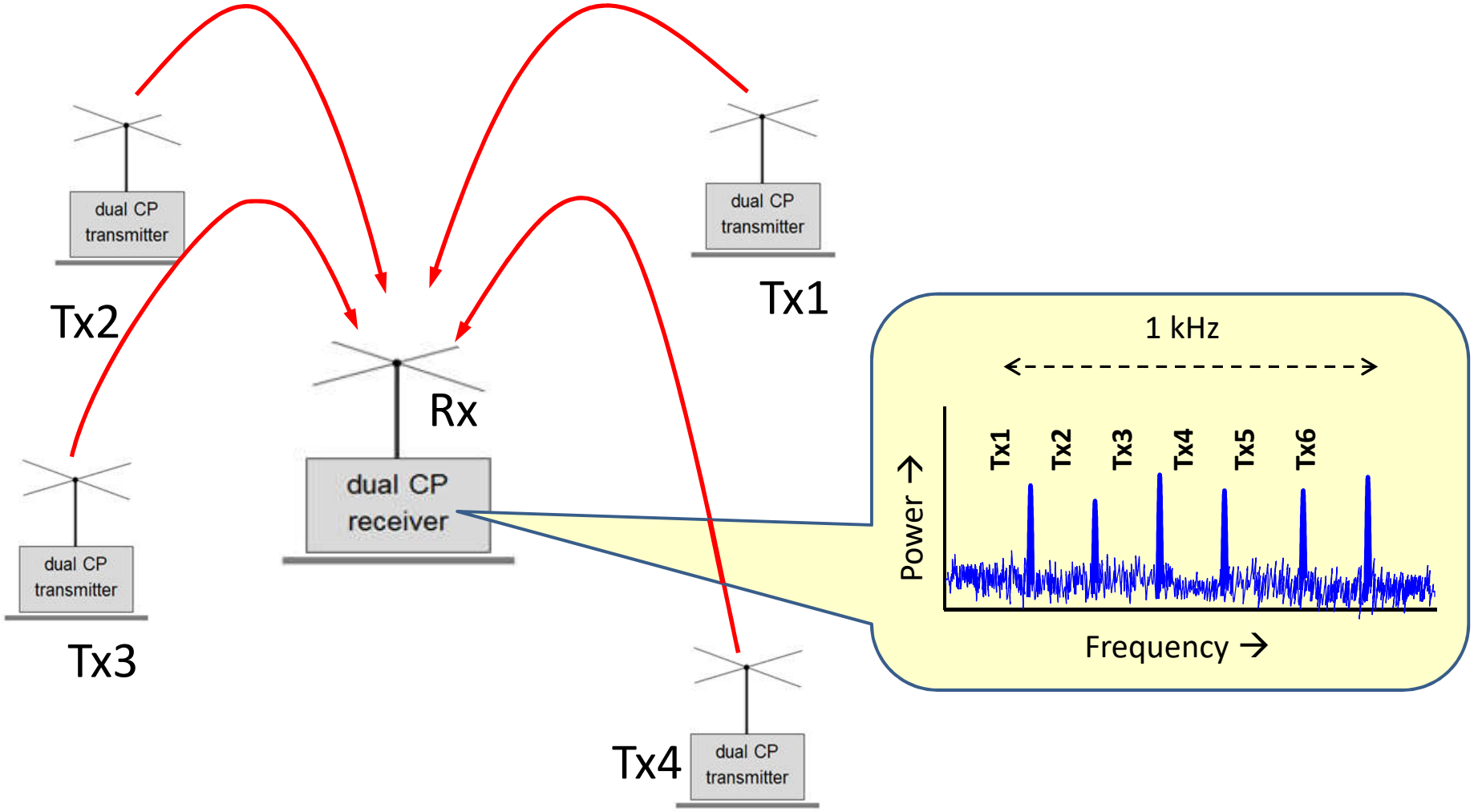
Earth's magnetic field tilt angle

The Netherlands

Barcelona, Spain

A very adventurous journey (third leg)

… and measure 6 paths simultaneously?



A very adventurous journey (third leg)

… and measure 6 paths simultaneously?

Cooperation with
LaSalle University
of Barcelona, Spain

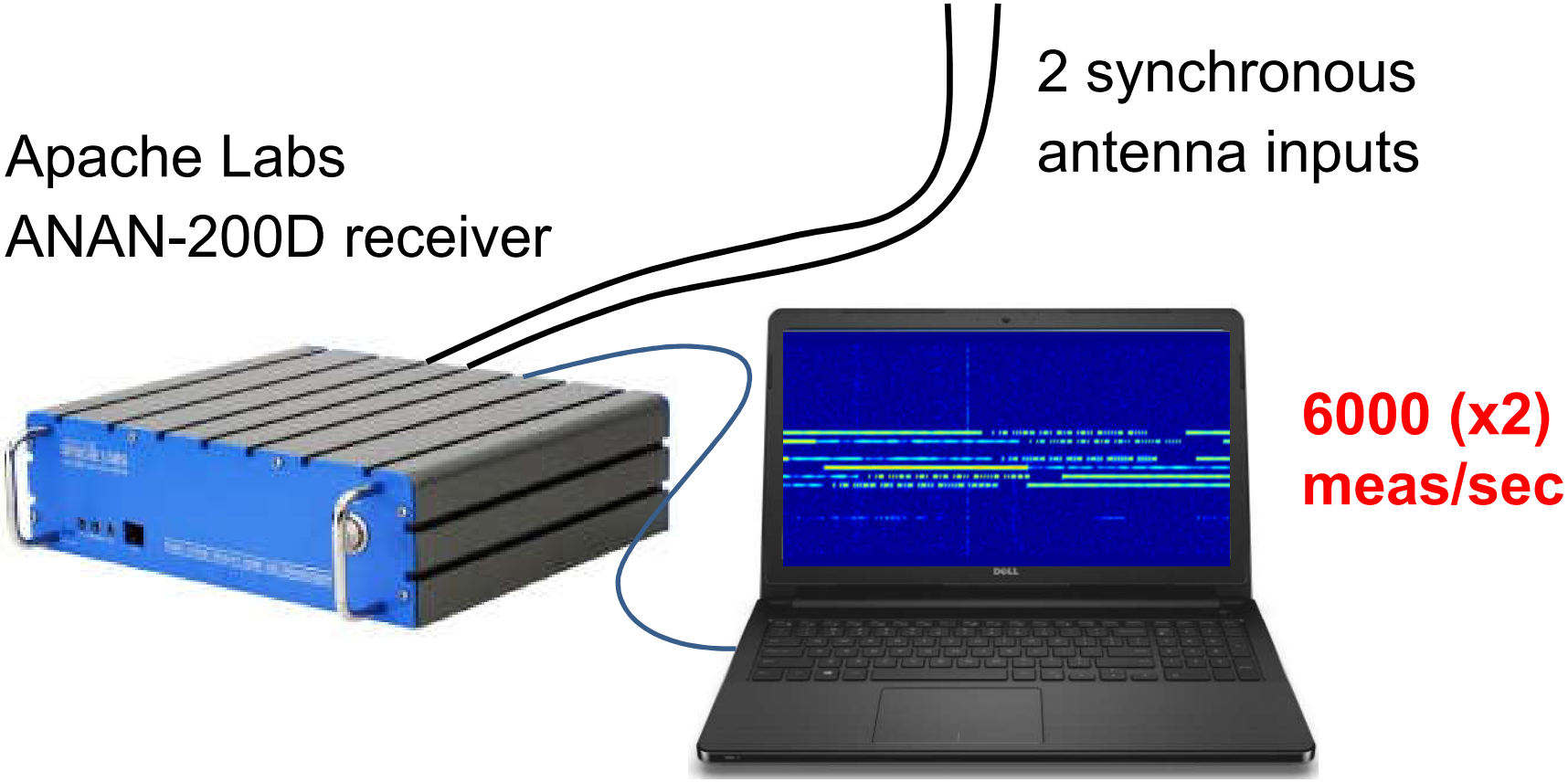
UNIVERSITY OF BATH

A very adventurous journey (third leg)

… and measure 6 paths simultaneously?

Apache Labs
ANAN-200D receiver

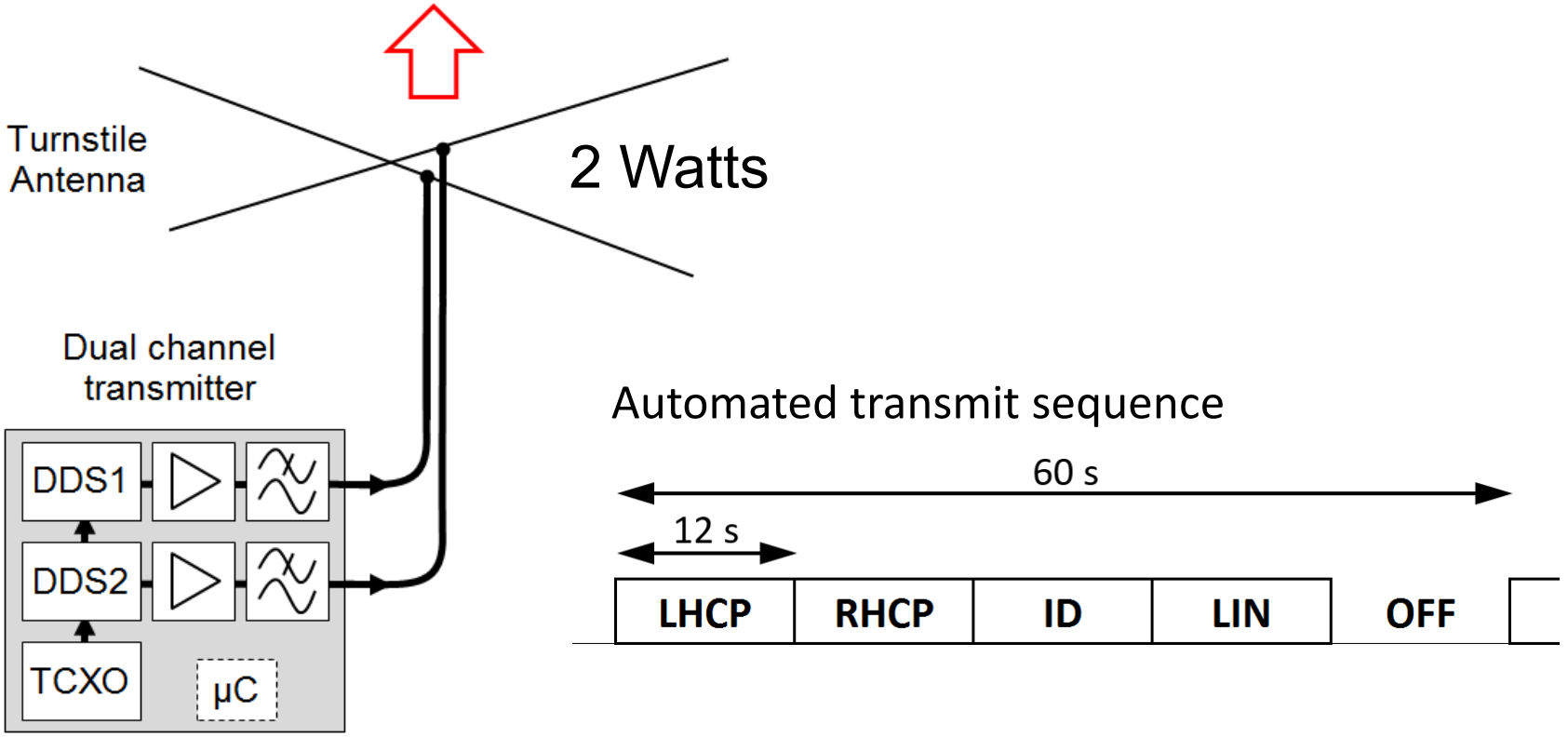
2 synchronous
antenna inputs



6000 (x2)
meas/sec

A very adventurous journey (third leg)

No more scrap-heap challenge transmitters!



Witvliet, Ben A., et al., "A transportable hybrid antenna-transmitter system for the generation of elliptically polarized waves for NVIS propagation research]," European Conference on Antennas and Propagation, Davos, 2016.

UNIVERSITY OF BATH

A very adventurous journey (third leg)

No more scrap-heap challenge transmitters!

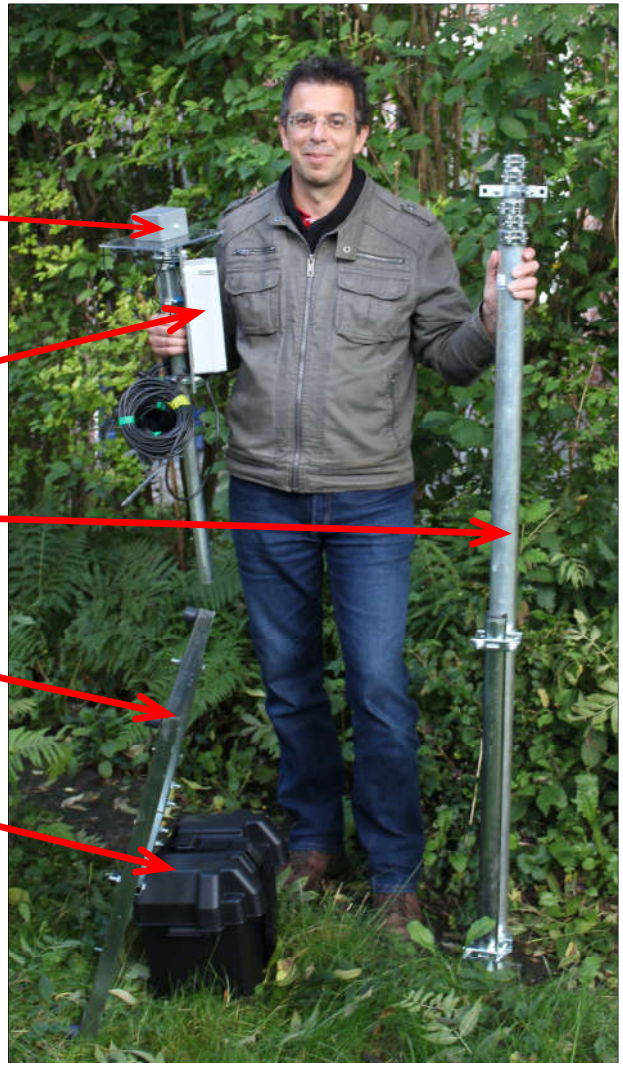
Wire antenna elements and baluns

Beacon transmitter

Mast 6.3 m

Mastfoot

Battery

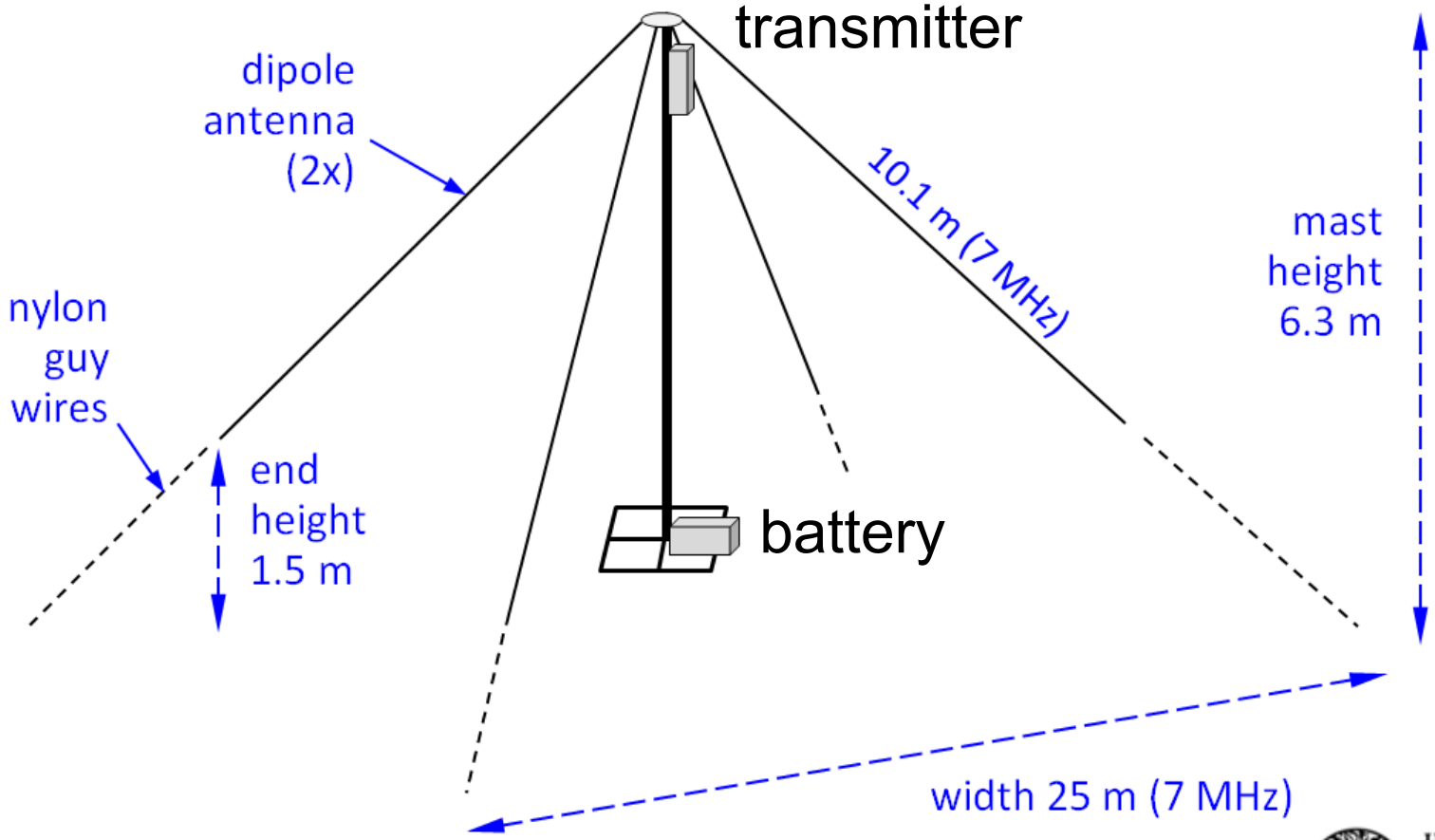


Radiocommunications Agency Netherlands

UNIVERSITY OF BATH

A very adventurous journey (third leg)

No more scrap-heap challenge transmitters!



Witvliet, Ben A., et al., "A transportable hybrid antenna-transmitter system for the generation of elliptically polarized waves for NVIS propagation research]," European Conference on Antennas and Propagation, Davos, 2016.

UNIVERSITY OF BATH

A very adventurous journey (third leg)

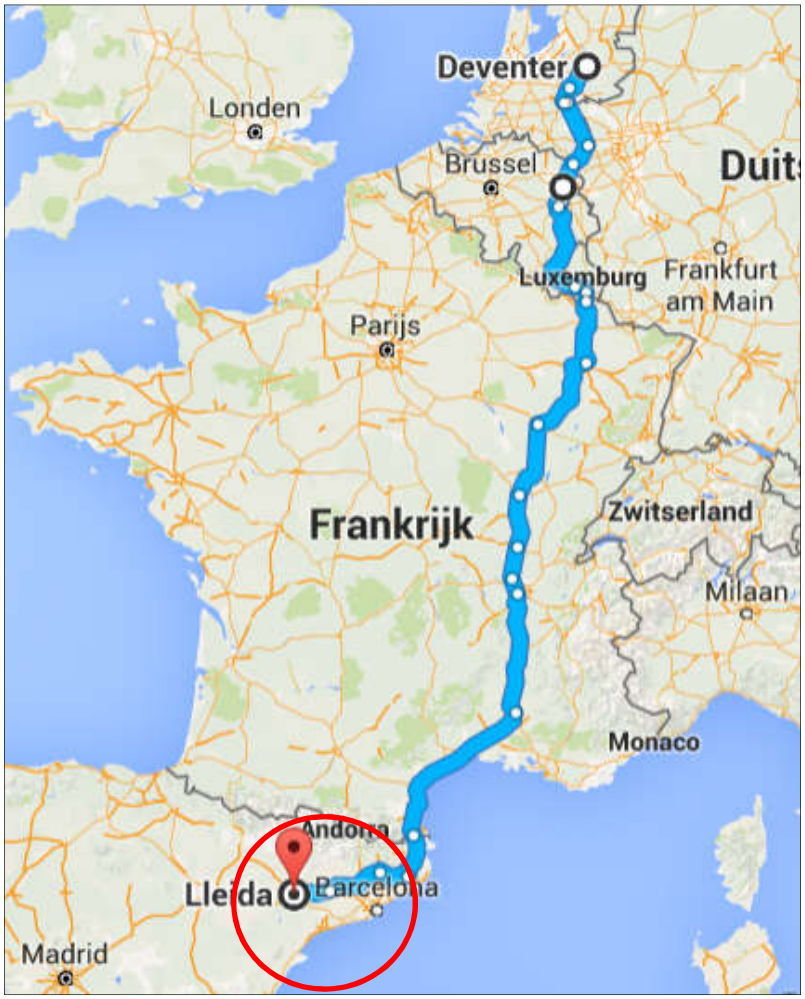
12 months later, time to hit the road!

8	antenna masts
16	dipole antennas
8	beacon transmitters
2	meas. receivers
10	batteries
32	guy wires
2	tool sets
(3	researchers)

A very adventurous journey (third leg)

12 months later, time to hit the road!

Travel to Spain	1800 km
Visit University Barça	200 km
Installing beacons	900 km
Retrieving beacons	900 km
Travel back	1800 km +
Total	**5600 km**
	(3,500 mls)



Radiocommunications Agency Netherlands

A very adventurous journey (third leg)

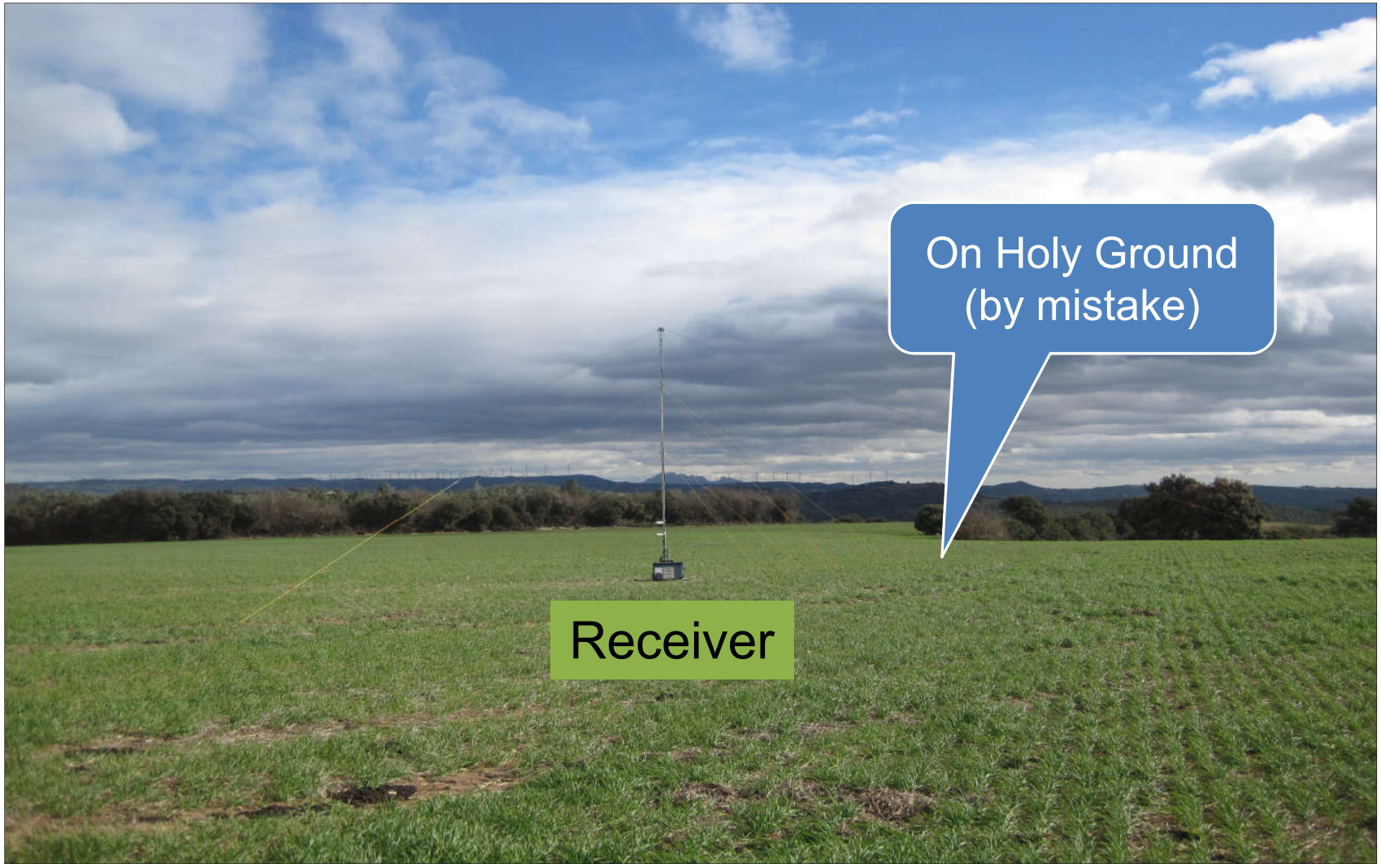
Interesting field work!

A very adventurous journey (third leg)

Interesting field work!

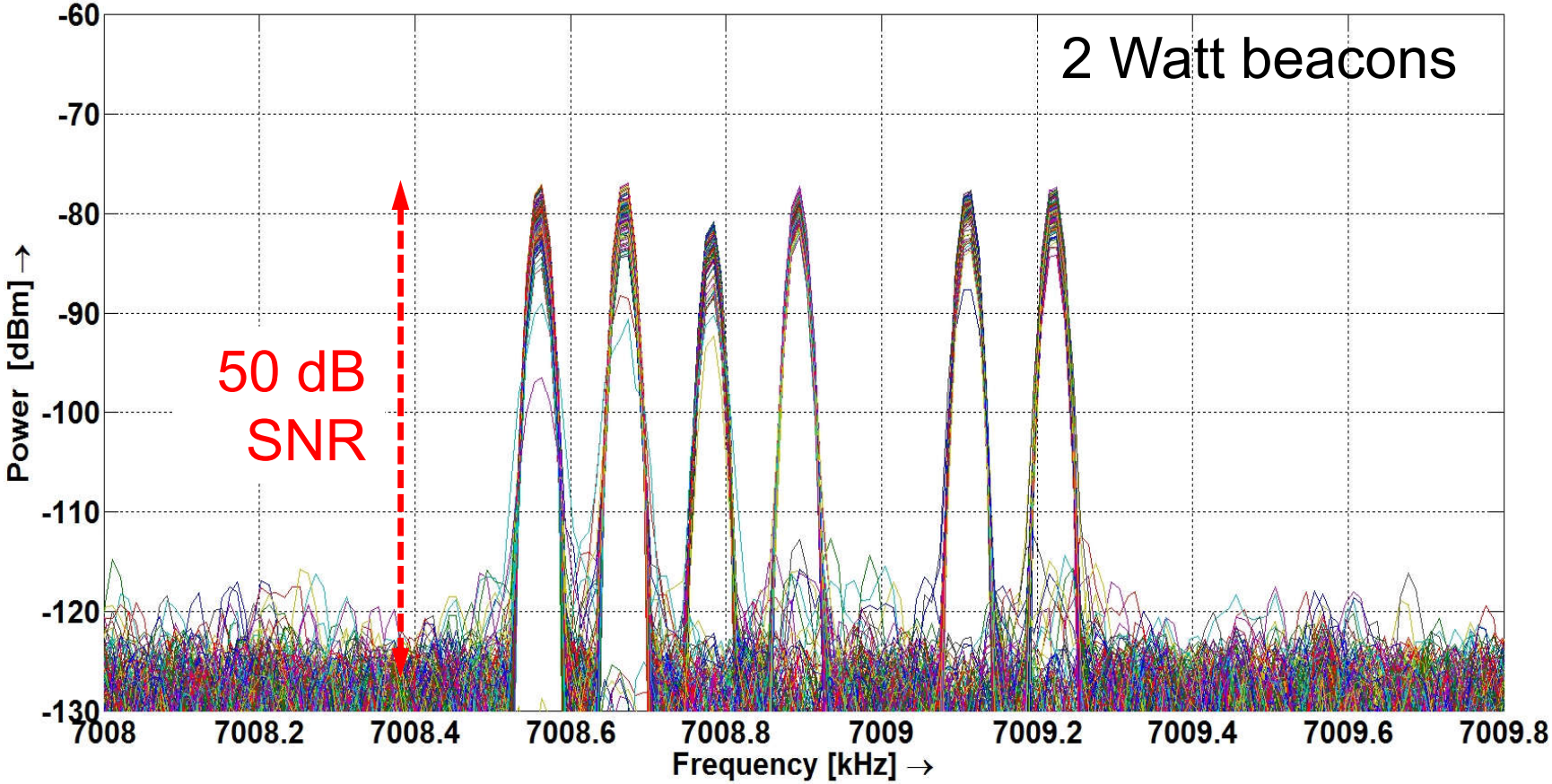
A very adventurous journey (third leg)

Interesting field work!



Results of the third leg

And interesting results!

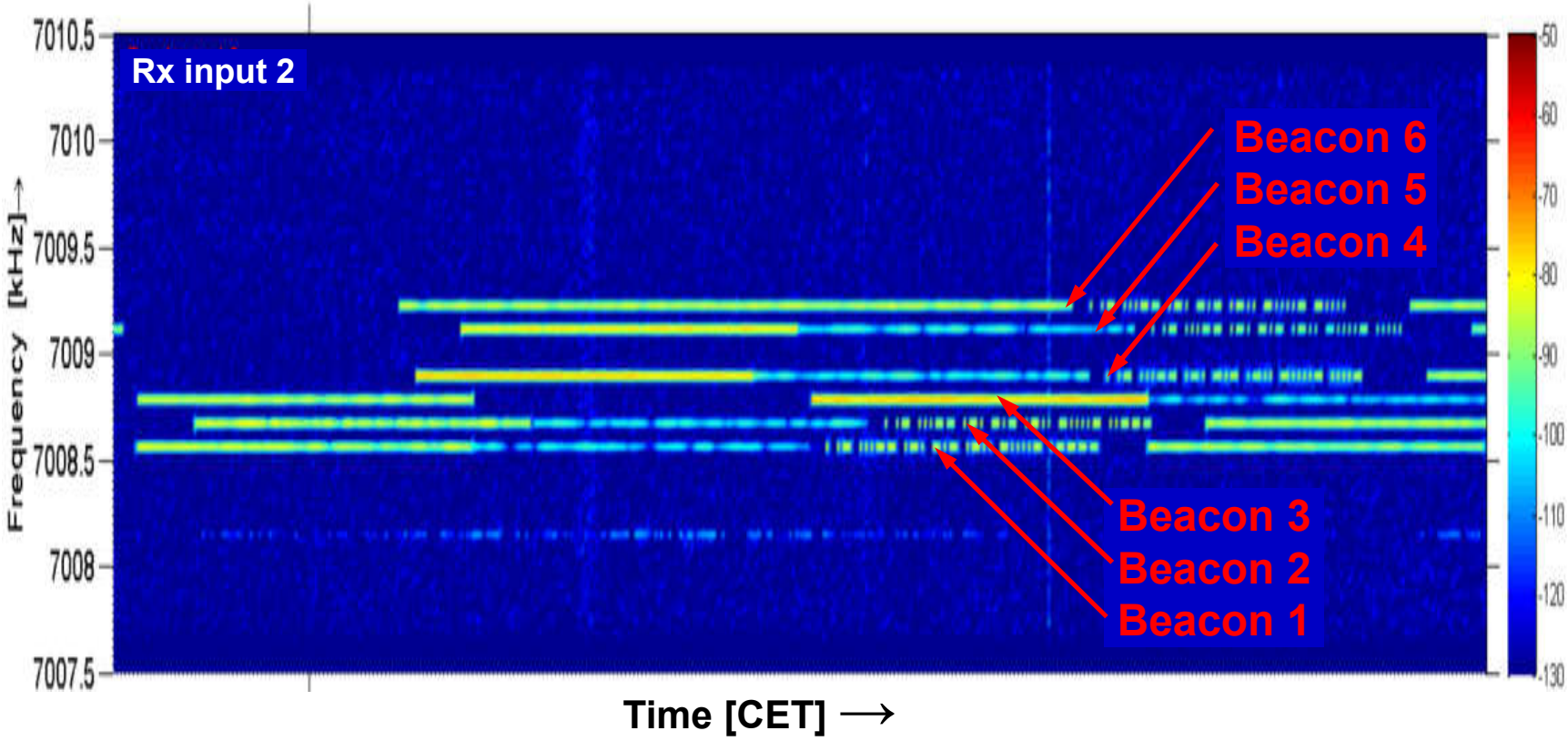


Radiocommunications Agency Netherlands

UNIVERSITY OF BATH

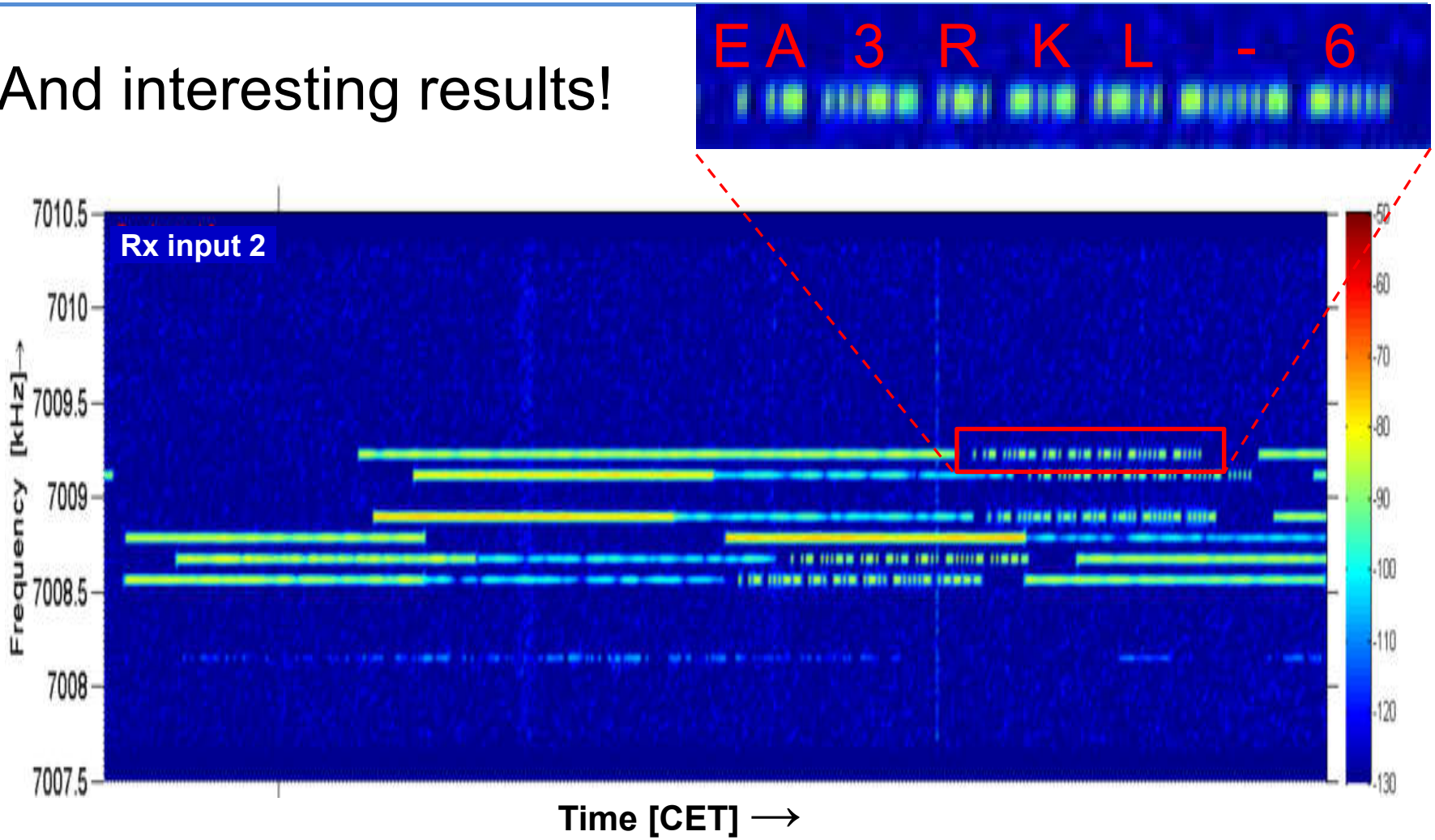
Results of the third leg

And interesting results!



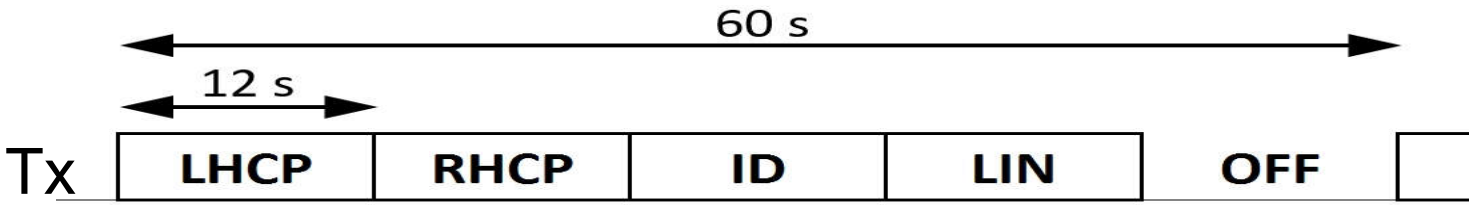
Results of the third leg

And interesting results!

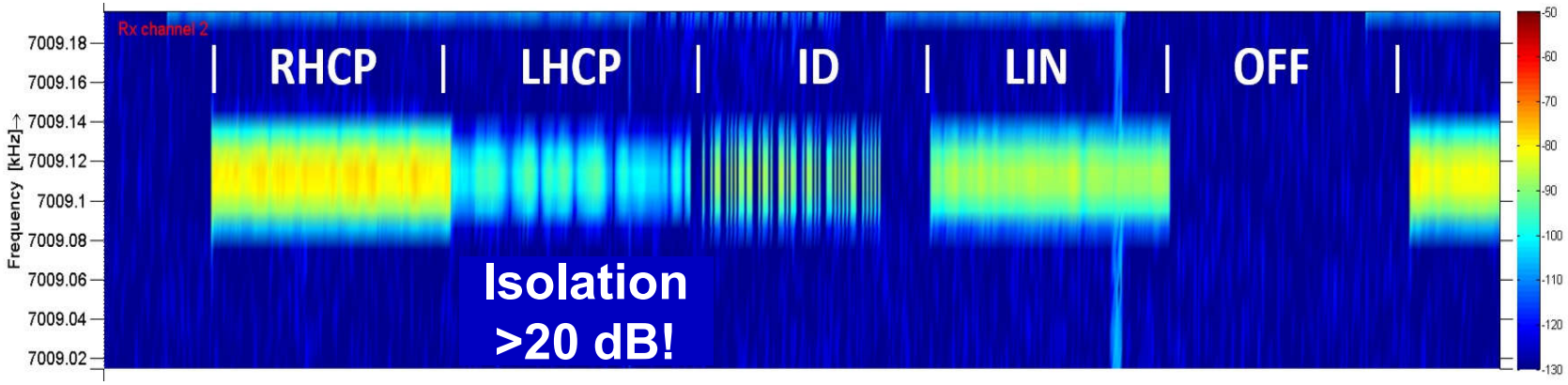


Results of the third leg

Morning Happy Hour, beacon 1



Happy Hour reception in linear polarization



Time ⟶

Results of the third leg

Interesting results

- Happy Hour propagation very well visible
- >20 dB isolation between ordinary and extraordinary wave
- Fading much more pronounced in linear polarization
- 2 Watt beacons produced excellent SNR

And they lived happily ever after…

What brought this adventure us?

- Increased knowledge of NVIS propagation
- New ideas to improve NVIS links
- Friendship with LaSalle University of Barcelona staff
- A lot of nice stories to tell

NVIS Field Research in Spain

Questions?

NVIS Field Research in Spain

Contact information

dr. ing. Ben A. Witvliet

email pe5b@xs4all.nl, b.a.witvliet@bath.ac.uk

Free publication download from

https://www.researchgate.net/profile/Ben_Witvliet/publications

NVIS Field Research in Spain

With thanks to:

The staff of the Roquettes, Dourbes and Juliusruh ionosondes, PAoA, PA5G, PA3DES, PAoSIR, Geert-Jan Laanstra and many others.

With thanks to the colleagues of Lasalle Ramon Llull Universitat de Barcelona (EA3RKL) for the excellent cooperation!

The NVIS research in Catalonia, Spain was sponsored by the European Association on Antennas and Propagation (EurAAP)