What's the difference?

Amateur radio and radio science

dr. Ben A. Witvliet [wit-fleet]
PE5B

University of Twente
The Netherlands

Radiocommunications
Agency Netherlands

dr. Ben Witvliet, PE5B

I've made my passion my work

Amateur radio

1973 NL4496 (SWL)
1981 PA3BXC
1982 3A/PA3BXC
1989 4X/PA3BXC
1993 5R8DS
1996 PA5BW
2013 PE5B

Telecom industry

Trans World Radio – Monte-Carlo

KPN Telecom – The Netherlands

Radio Netherlands – Madagascar

Netherlands BC Transmitter Co.

Applied research

Radiocommunications Agency Netherlands

50%

Academic research

University of Twente The Netherlands

University of Bath United Kingdom

50%

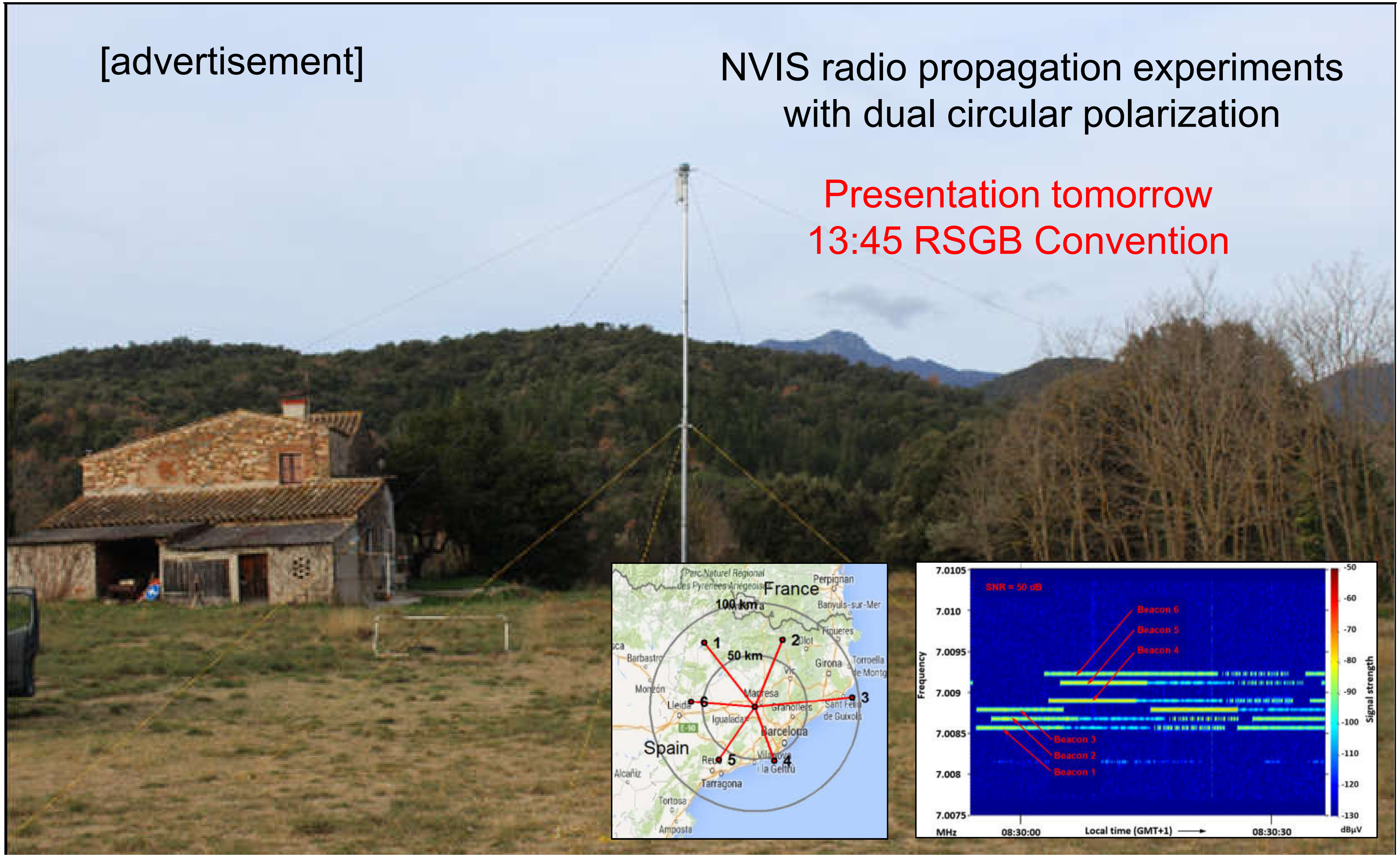
What's the difference?

Amateur radio and radio science

[advertisement]

NVIS radio propagation experiments
with dual circular polarization

Presentation tomorrow
13:45 RSGB Convention



Central question of this presentation:

How can amateur radio experiments make significant contributions to radio science?

To be demonstrated:

This does not require expensive lab equipment, but mainly a change in mind-set.

Contents

1. Amateur radio and radio science

Radio amateurs have valuable hands-on experience

- Spectrum management
- Radio wave propagation
- Noise and interference
- Antennas
- Transmitter and receiver performance
- Modulation / demodulation

They tend to be very enthusiastic about radio experiments, and are great in improvising new equipment for experiments.

Sometimes adhere to unverified "experience-based opinions".

1. Amateur radio and radio science

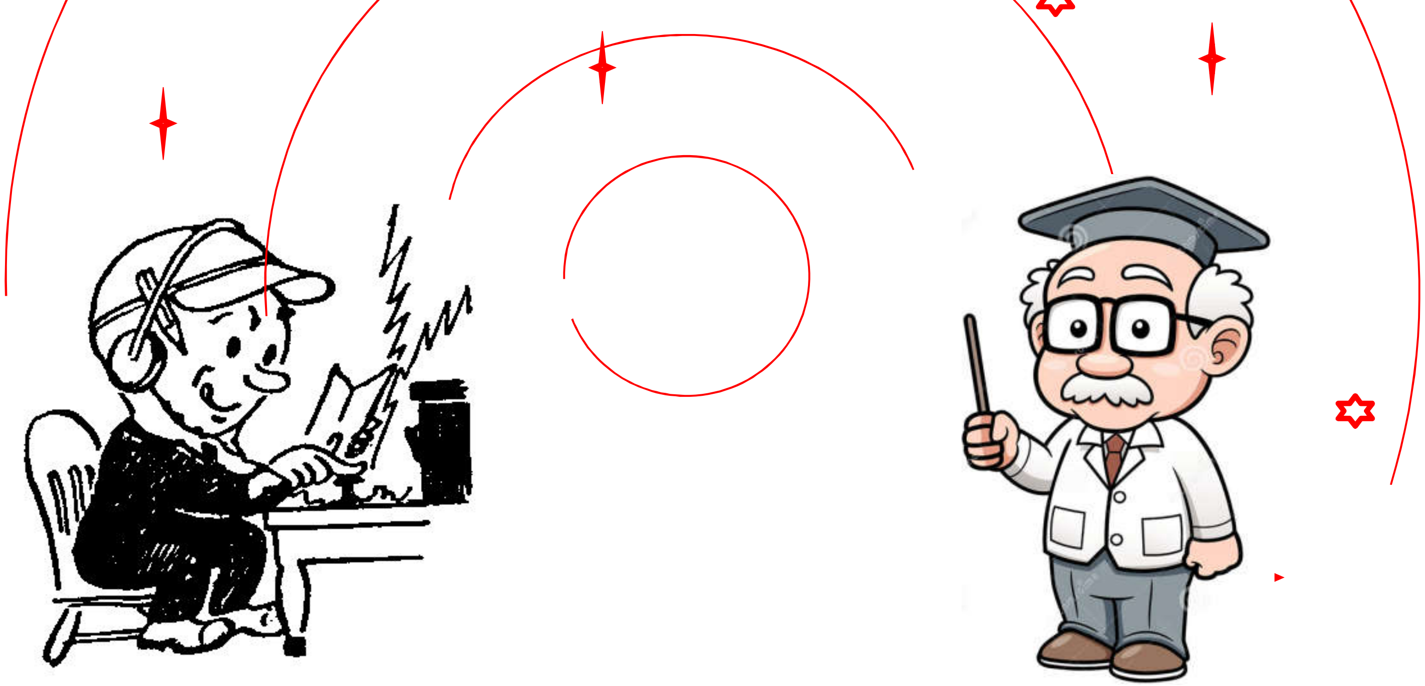
Radio scientists have essential research skills

- Theoretical knowledge
- Access to the latest research
- Mathematical methods
- Scientific rigor and objectivity
- A network of peers to check their work

They tend to be enthusiastic about formulas
and theoretical solutions, and are rather serious about their work.

Sometimes lack the practical experience.

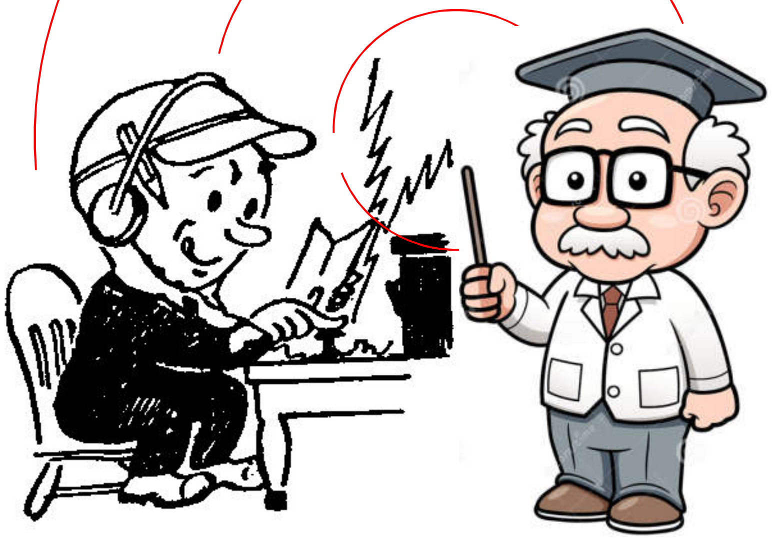
1. Amateur radio and radio science



A fusion between those two would create magic!

(but cooperation would also do ☺)

1. Amateur radio and radio science



A fusion between those two would create magic!

(but cooperation would also do ☺)

2. Reliable scientific building blocks

Science is about
knowledge of the world around us

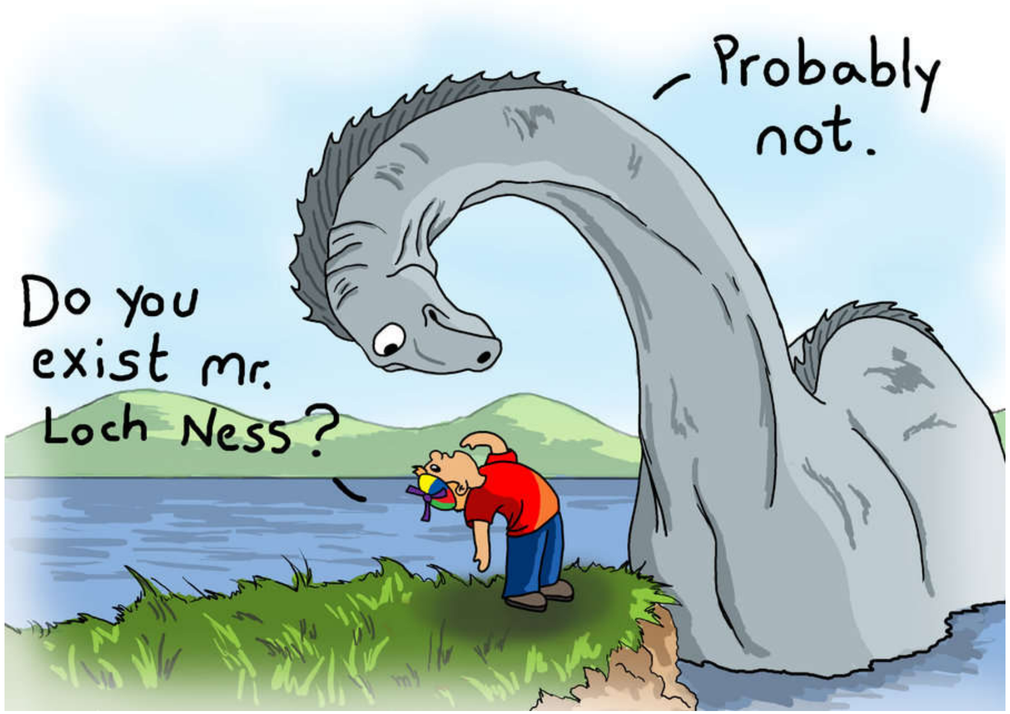
But to reach high

Science needs
reliable building blocks

2. Reliable scientific building blocks

Empirical verification

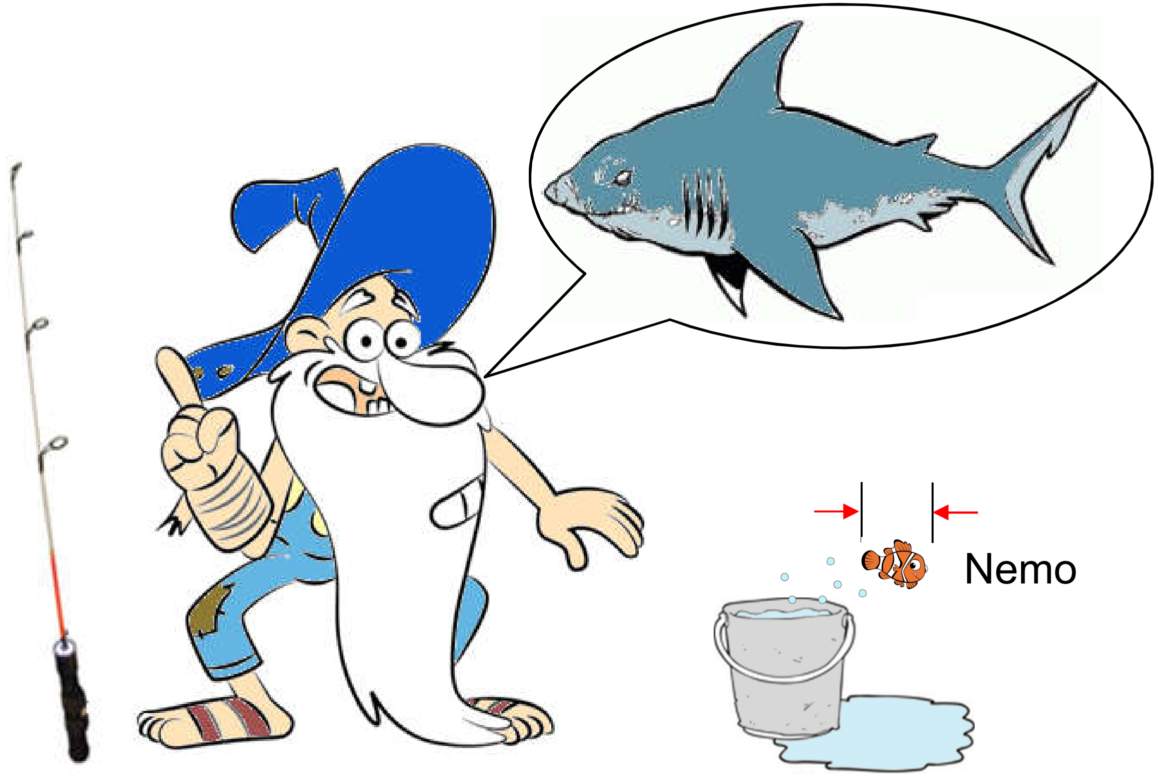
- Hypothesis
- **Experiment**
- Analysis
- Peer review
- Publication



2. Reliable scientific building blocks

Peer review of claimed results

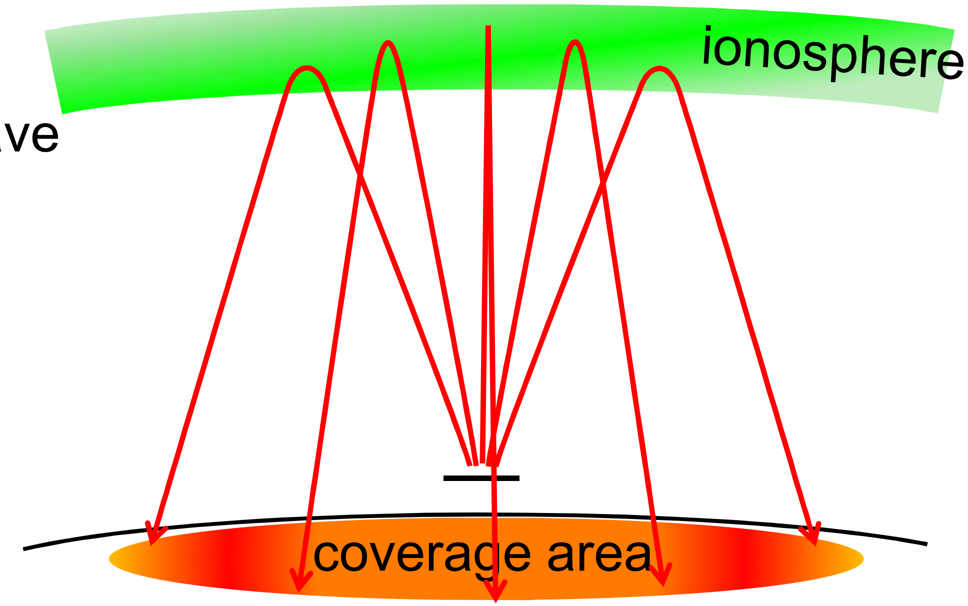
Hypothesis
Experiment
Analysis
Peer review
Publication



3. "Experience-based opinions"

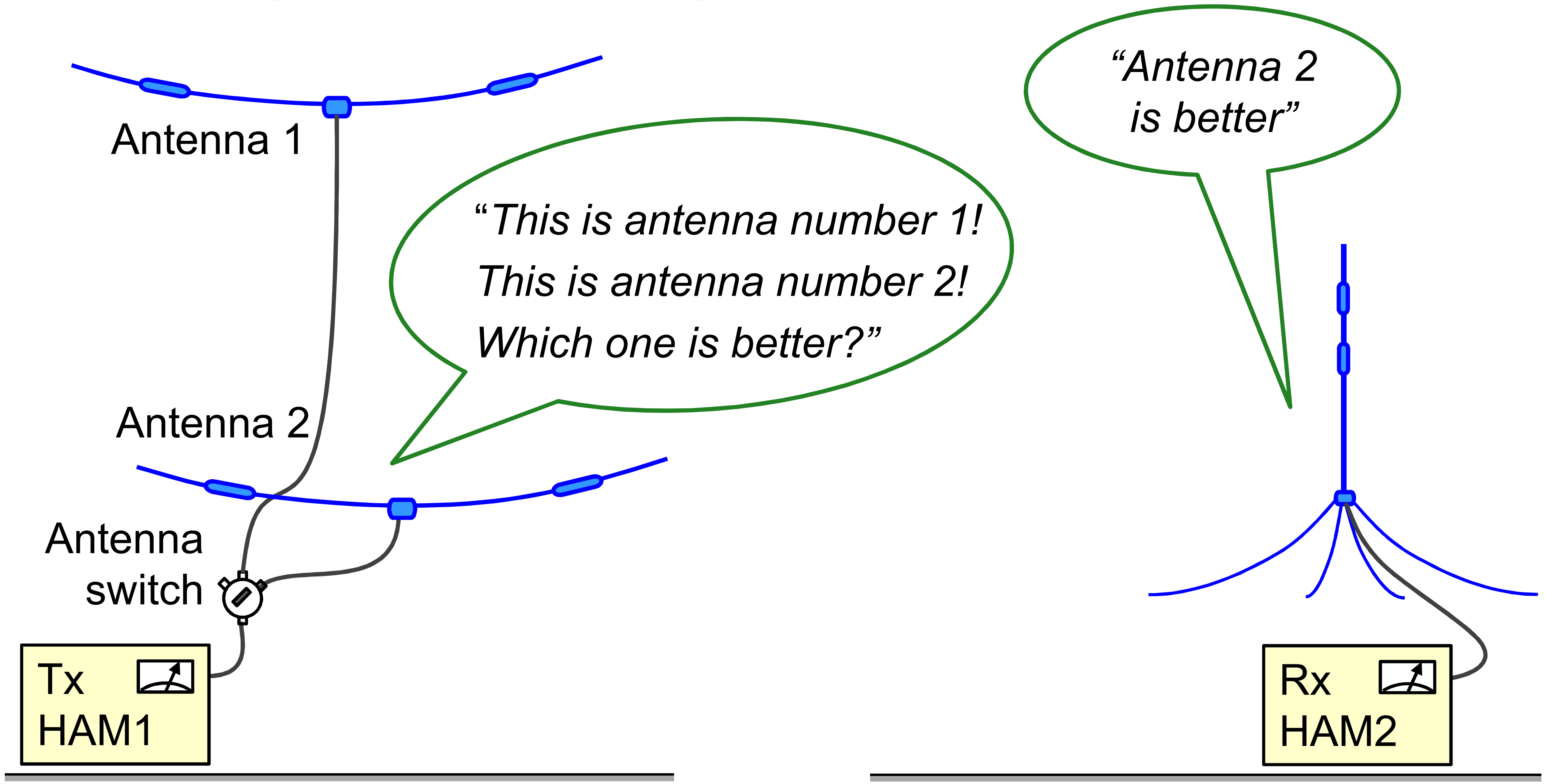
Brief experiments with lots of uncontrolled variables may lead to "experience-based opinions" or myths.

Example from
Near Vertical Incidence Skywave (NVIS) propagation research

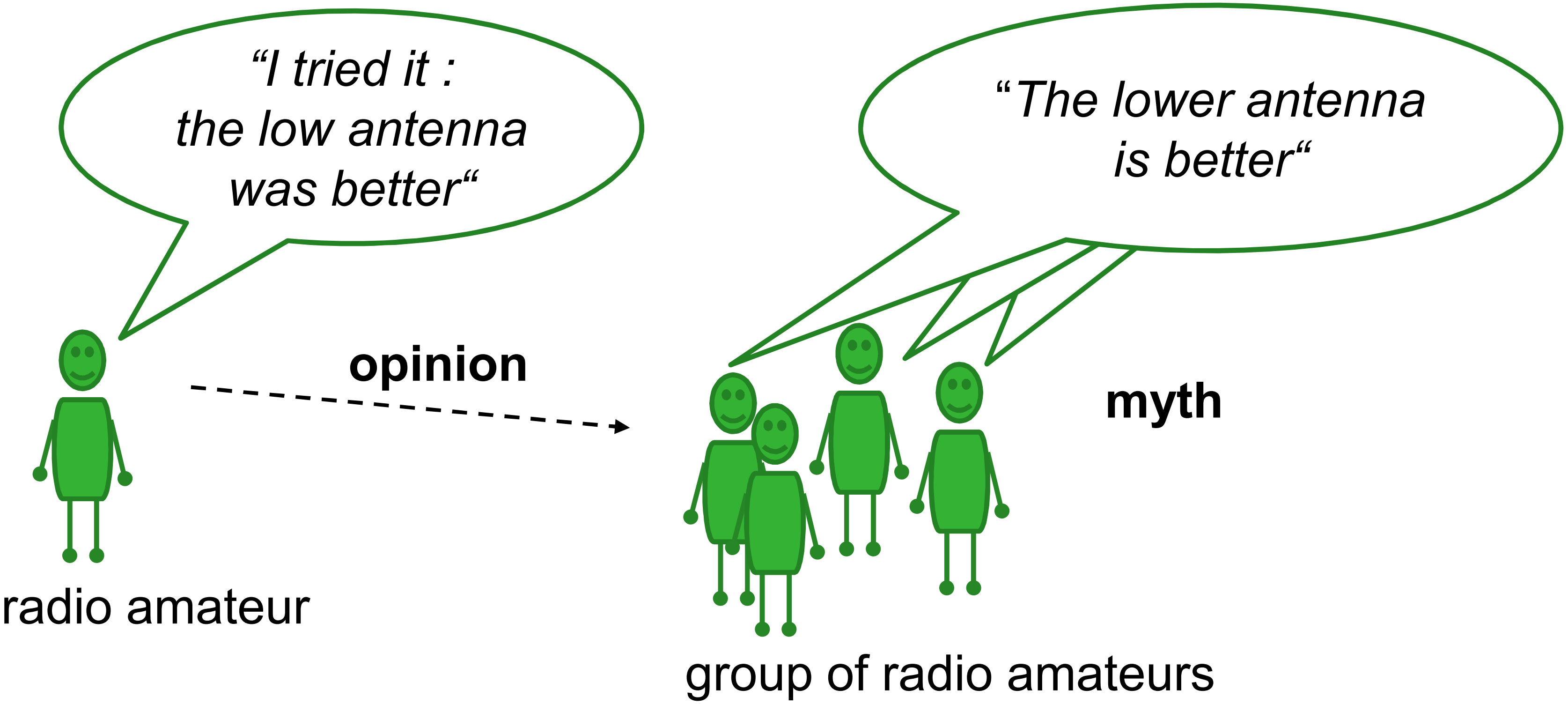


Myth:
The NVIS antenna must be installed as low as possible

3. "Experience-based opinions"



3. "Experience-based opinions"



Myths can have
serious consequences e.g. for disaster relief communications!

3. "Experience-based opinions"

Many uncontrolled variables:

Antennas under test

- Coupling between the antennas
- Buildings in proximity

Transmitted test signal

- Voice power not constant
- Cable loss not identical
- Loading impedance different

Radio wave propagation

- Multipath fading
- Variation of elevation angle
- Ground wave component

Measurement

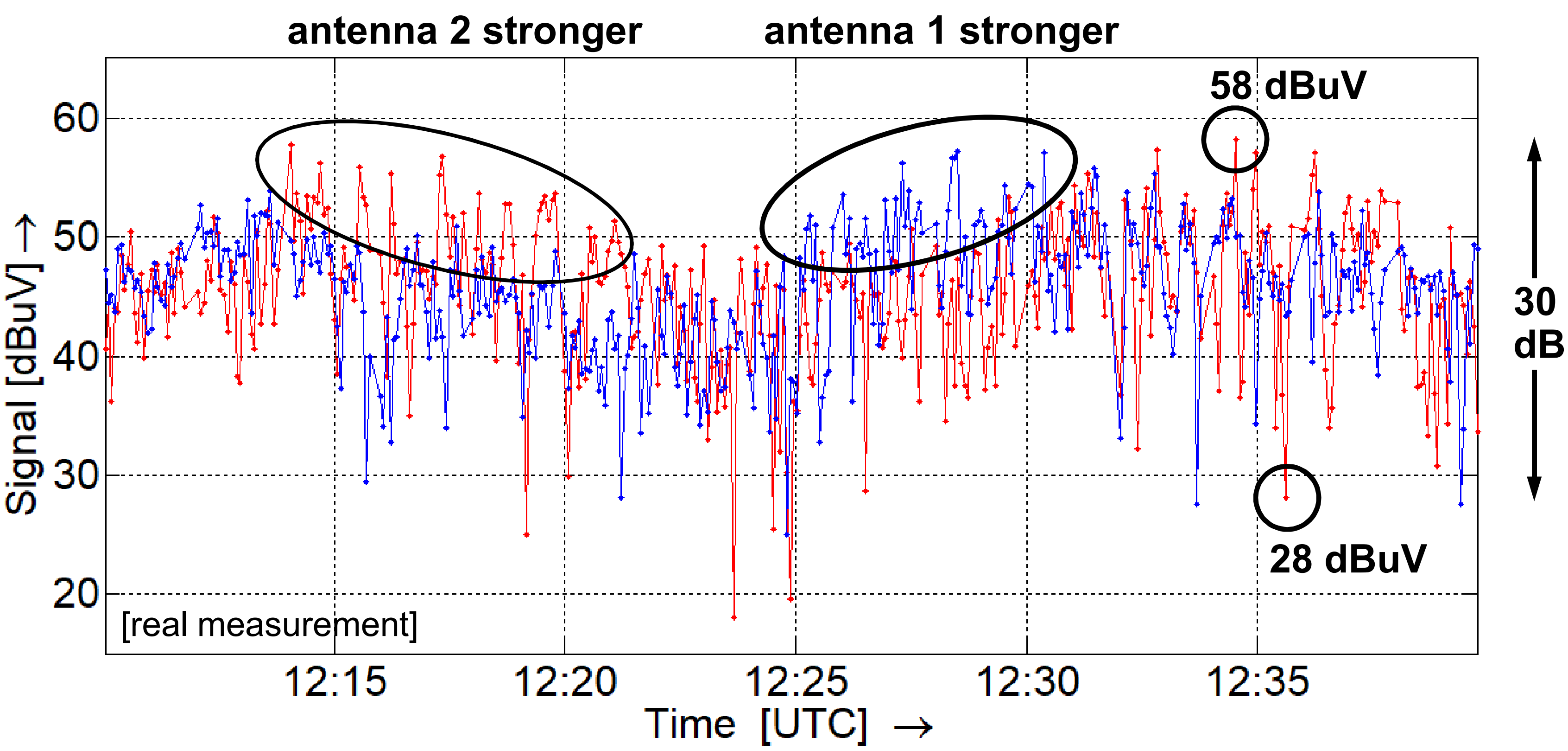
- Wrong receive antenna
- Poor meter linearity
- Sample, average, peak, RMS?
- Interference

Methodology

- Very few observations
- Manual observations

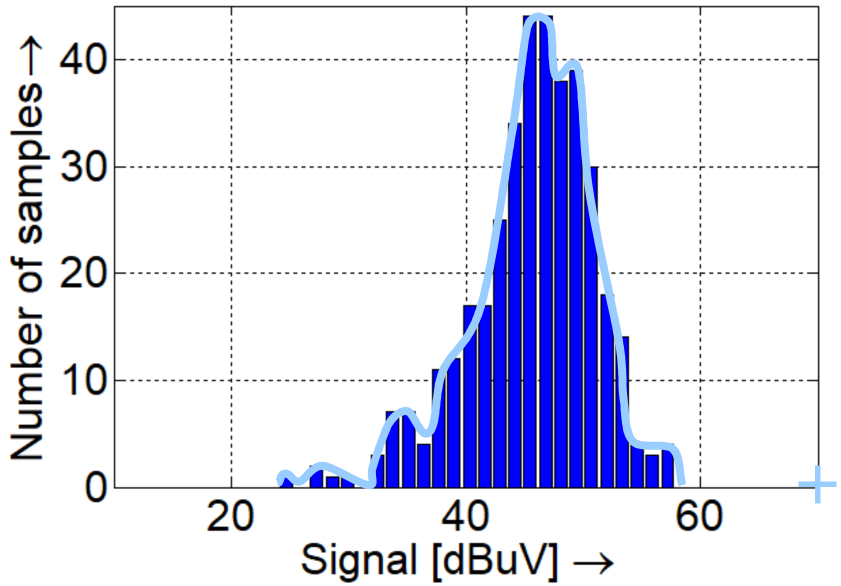
3. "Experience-based opinions"

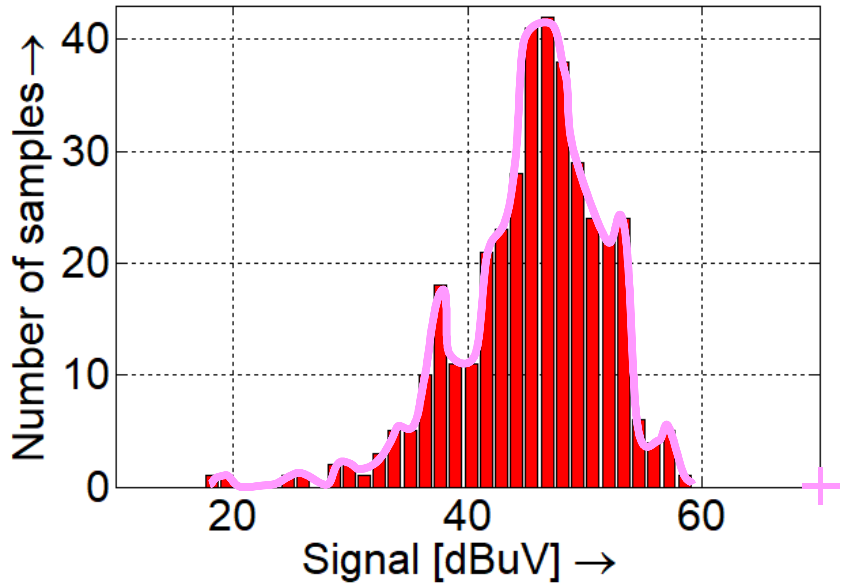
Short-term ionospheric signal comparisons are meaningless



4. A practical experiment

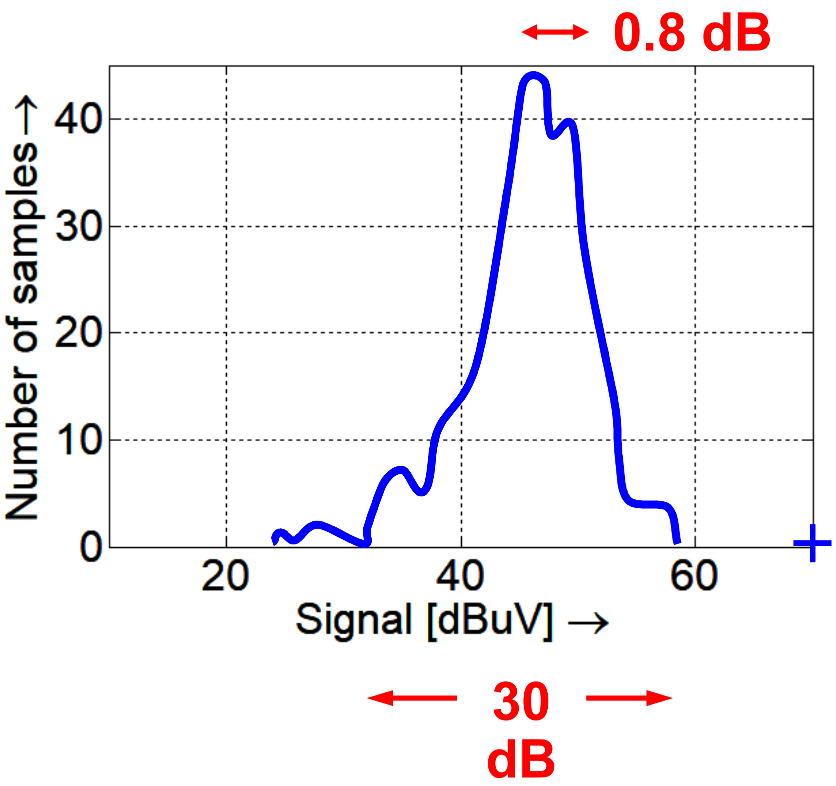
But histograms will provide information on mean value <ins>and</ins> fading

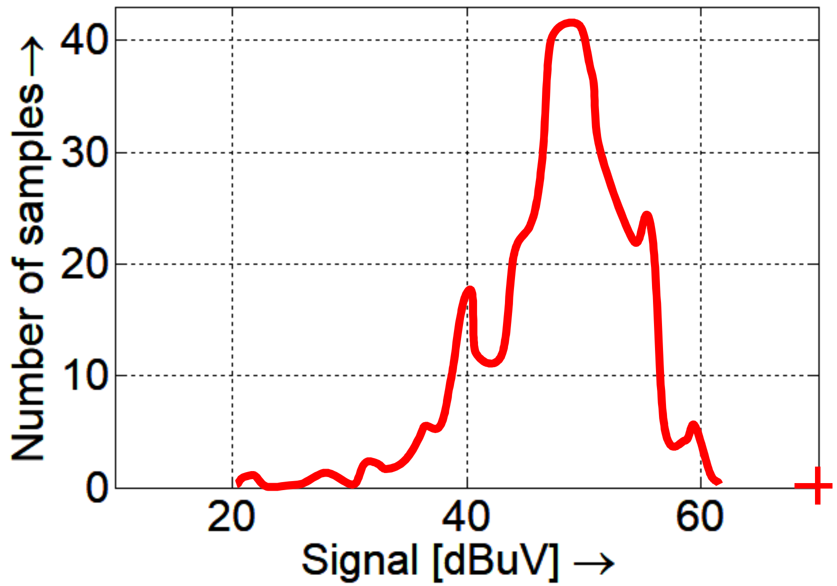




4. A practical experiment

And allow a fair comparison





4. A practical experiment

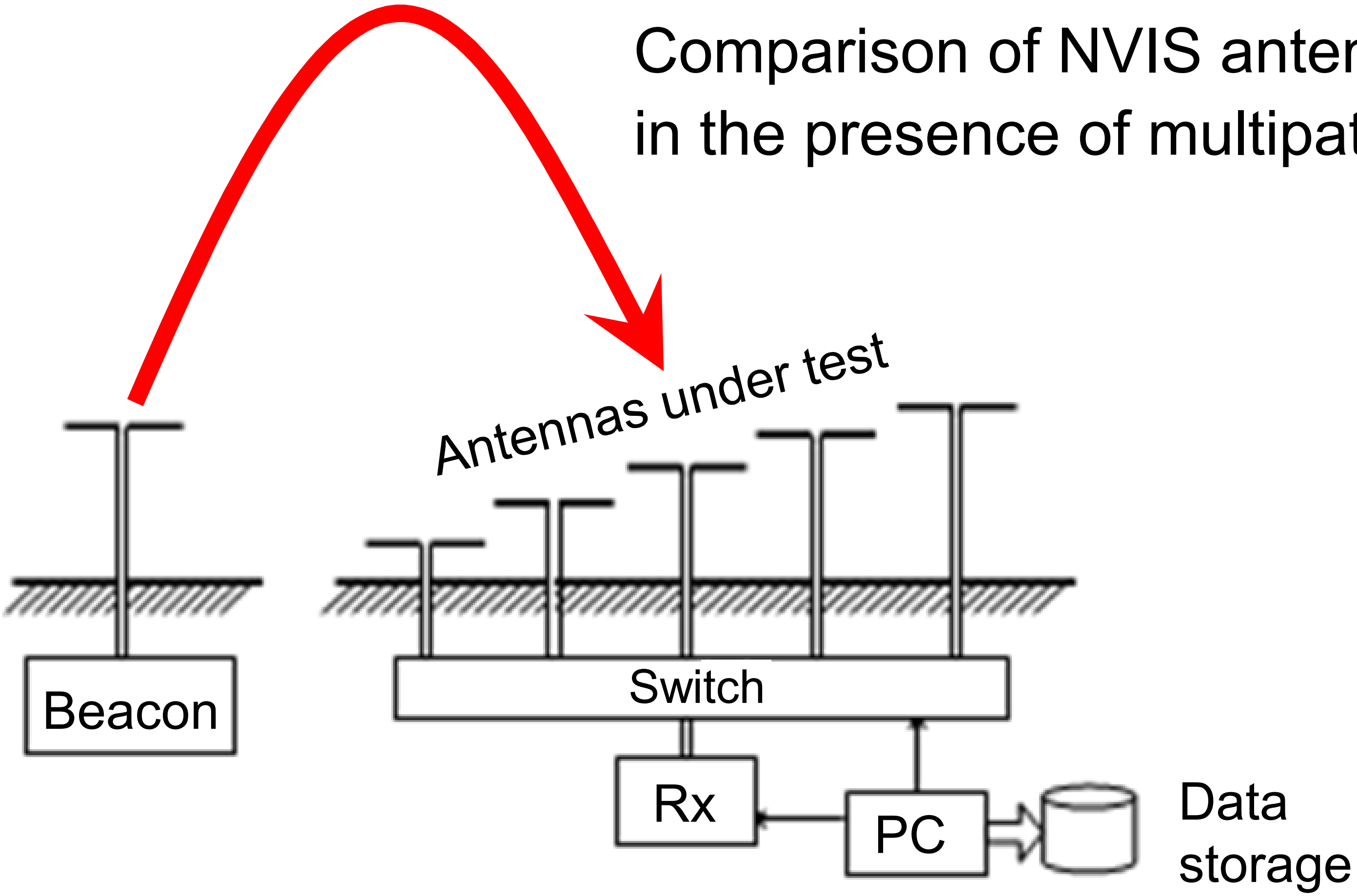
Research verification with a clear research question

To be verified:
The optimum antenna height for NVIS propagation
is **between 0.18 λ and 0.22 λ** above farmland

Myth to be countered:
not "as low as possible"

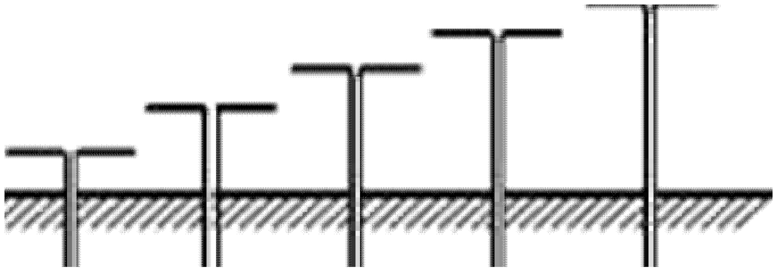
4. A practical experiment

Comparison of NVIS antenna gain in the presence of multipath fading



4. A practical experiment

Antennas under test

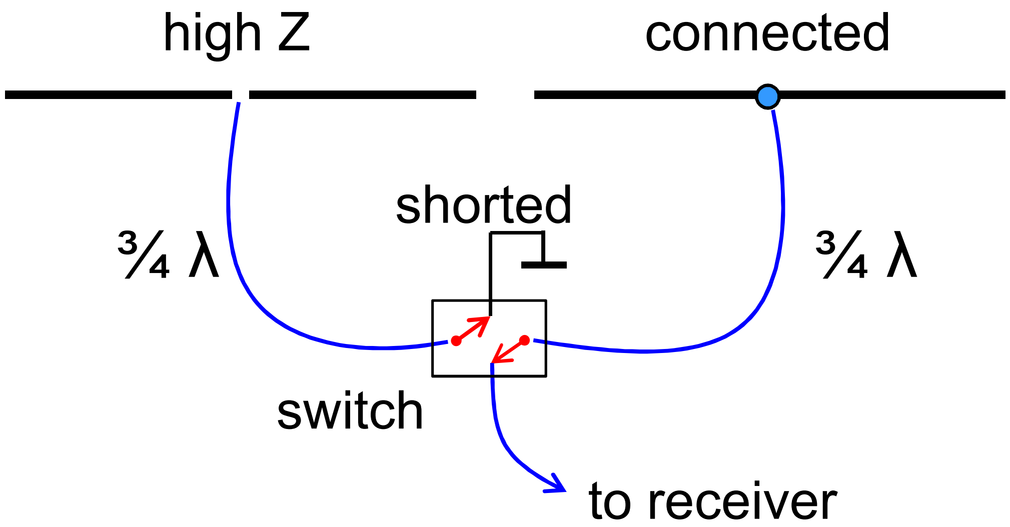


Heights: 1, 3, 5, 9 and 12.5 m,
0.02, 0.05, 0.09, 0.16 and 0.22 λ.

Soil: farmland (σ=20 mS/m, ε_r=17).

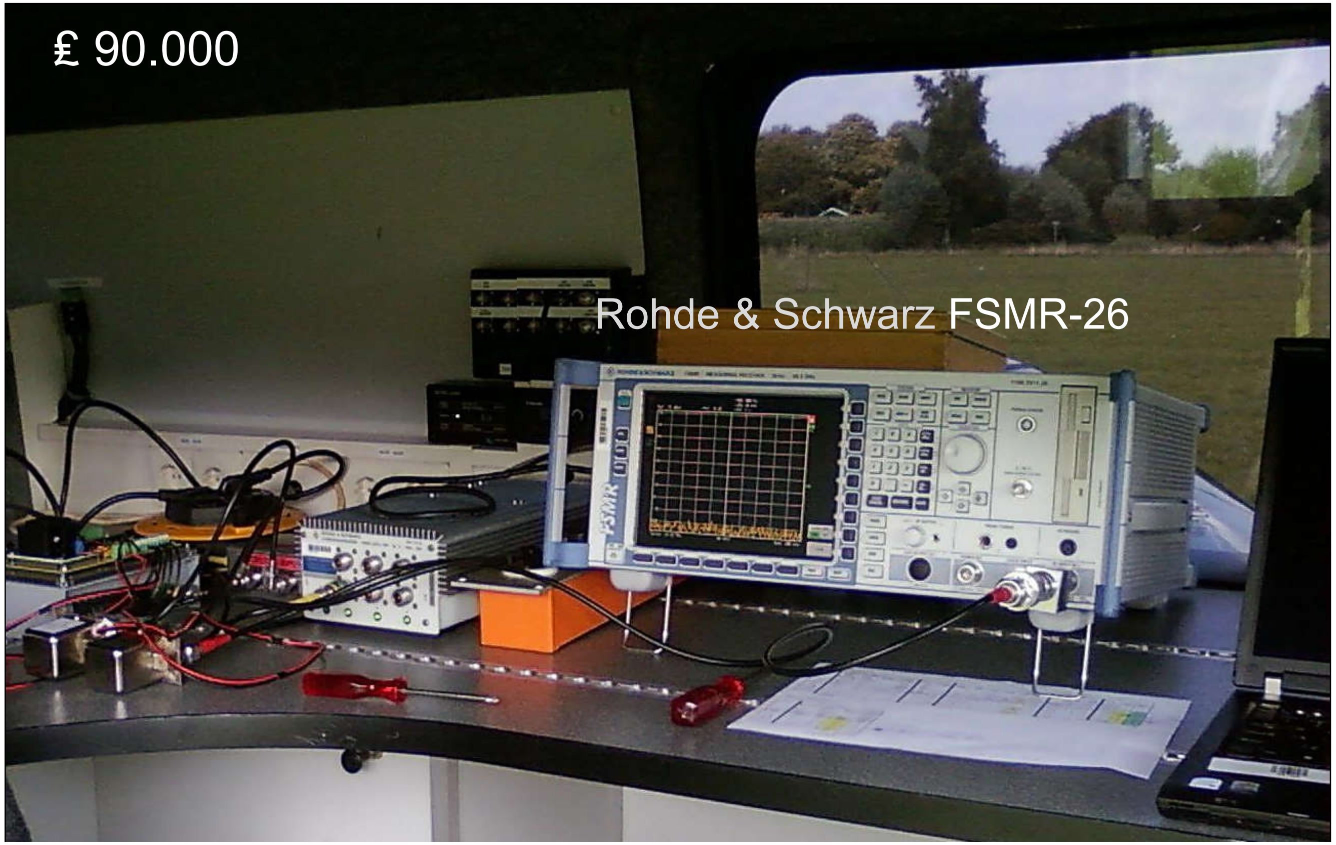
4. A practical experiment

Detuning of unused dipole antennas



4. A practical experiment

Measurement receiver and automation



Labview
software
PA3DES

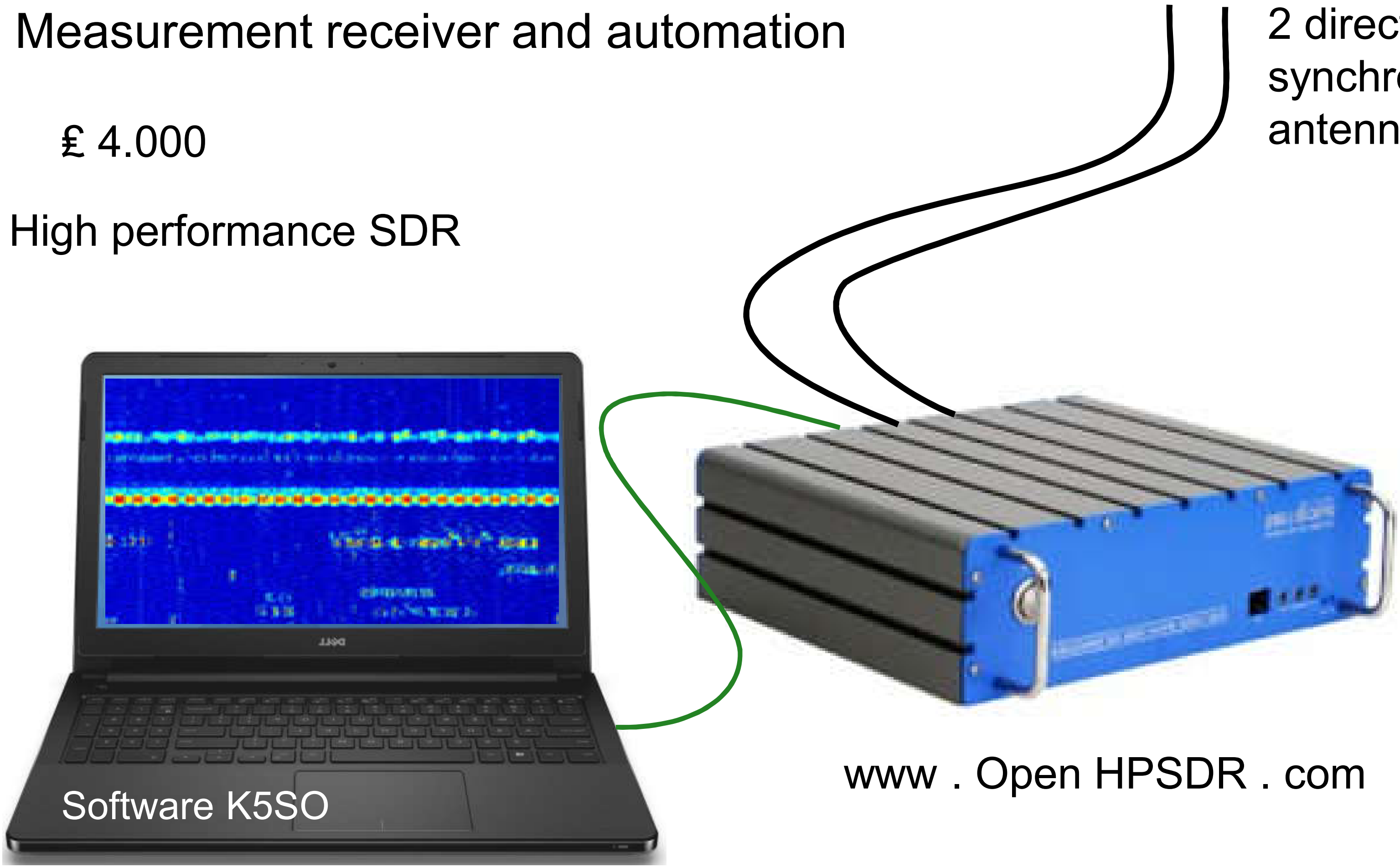
4. A practical experiment

Measurement receiver and automation

£ 4.000

High performance SDR

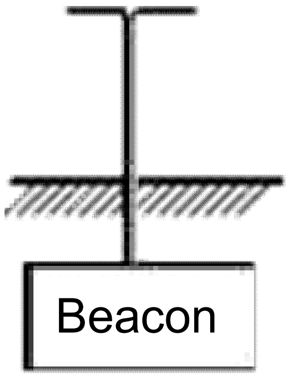
2 directly sampled synchronous antenna inputs



www . Open HPSDR . com

4. A practical experiment

Stable beacon transmitter



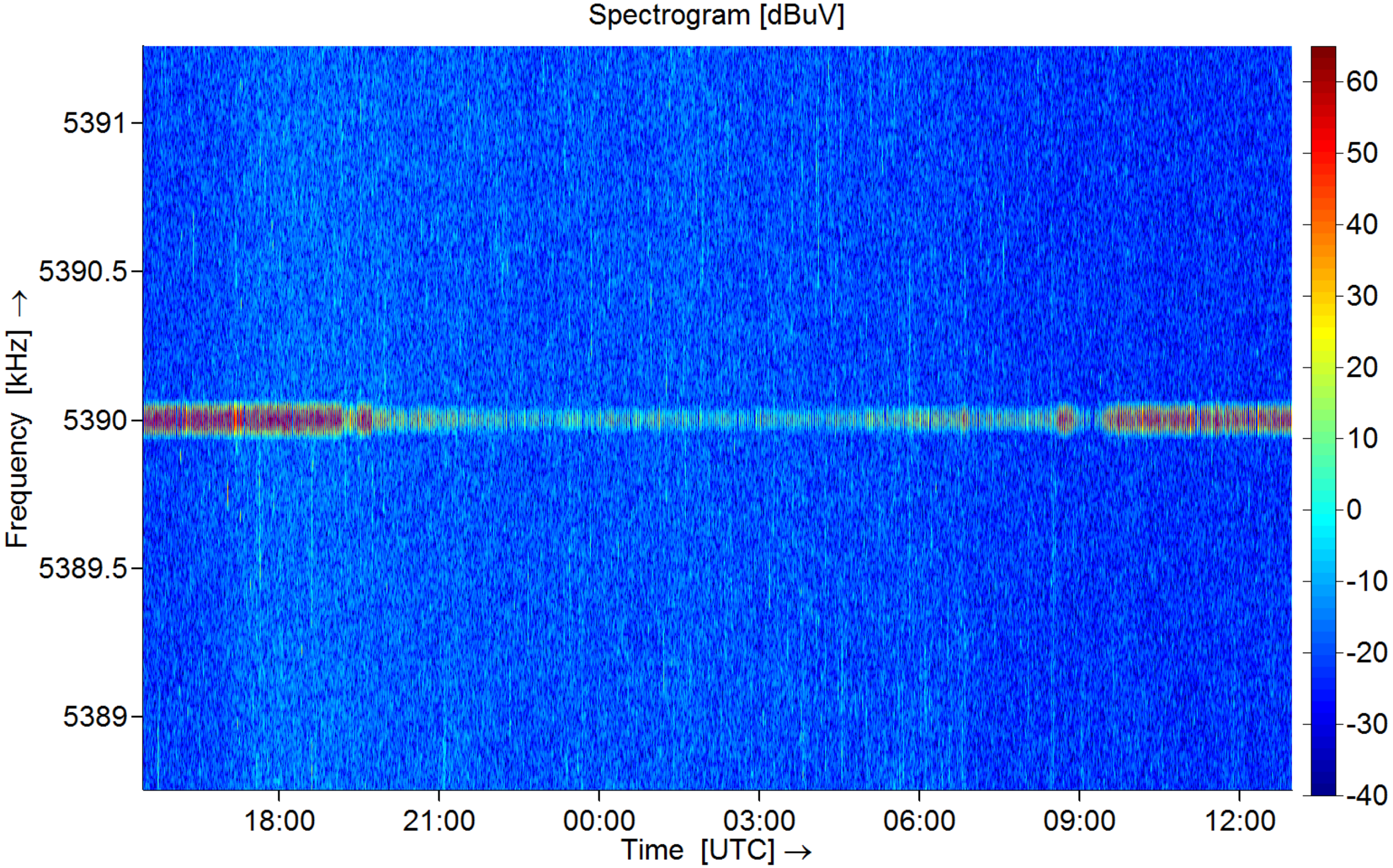
P = 800 Watts, $\Delta P < 0.1$ dB
f = 5.39 MHz, $\Delta f < 5$ Hz

1 minute on / 1 minute off
DCF controlled timing

design PAoA

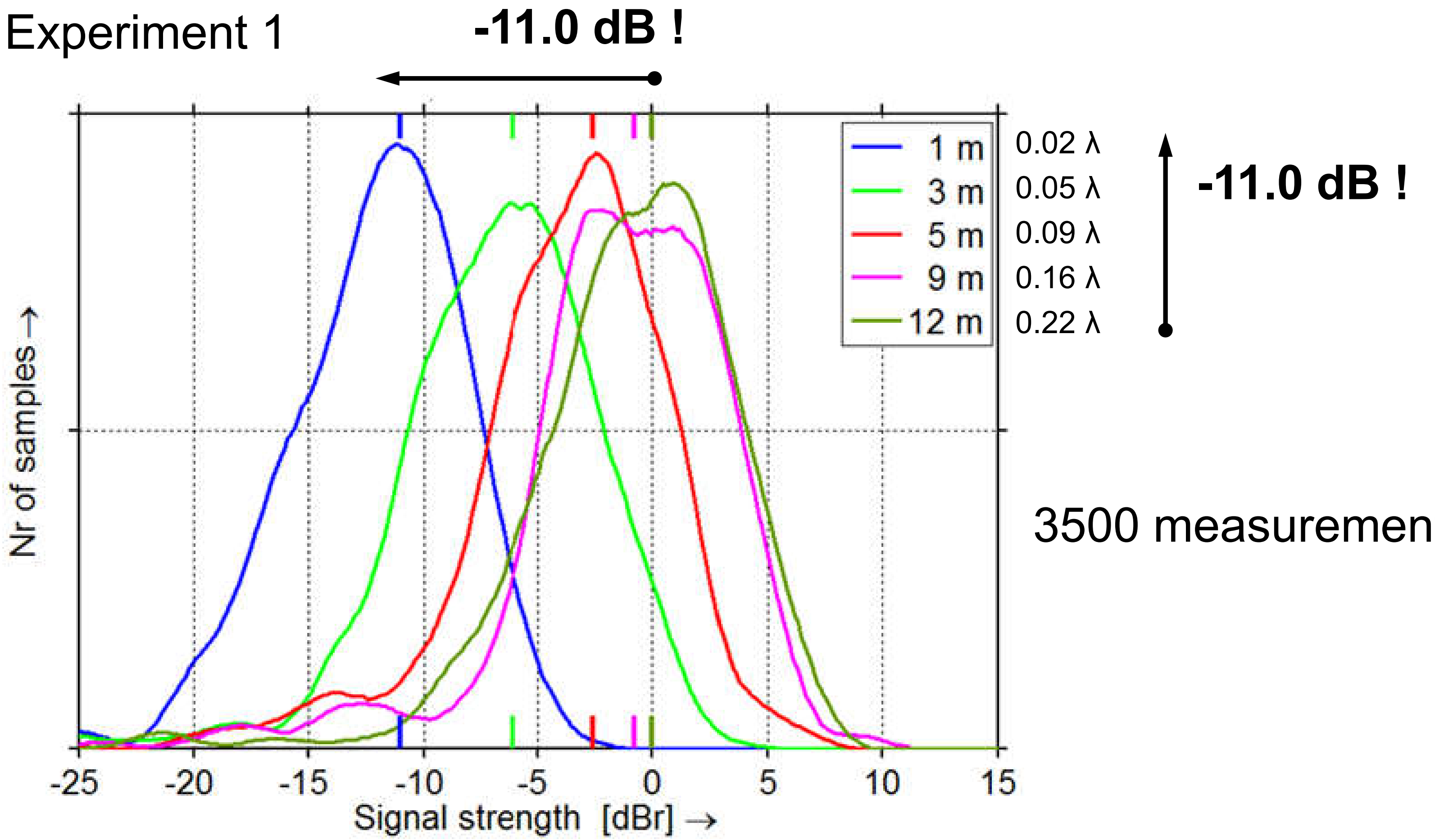
4. A practical experiment

Interference monitoring



4. A practical experiment

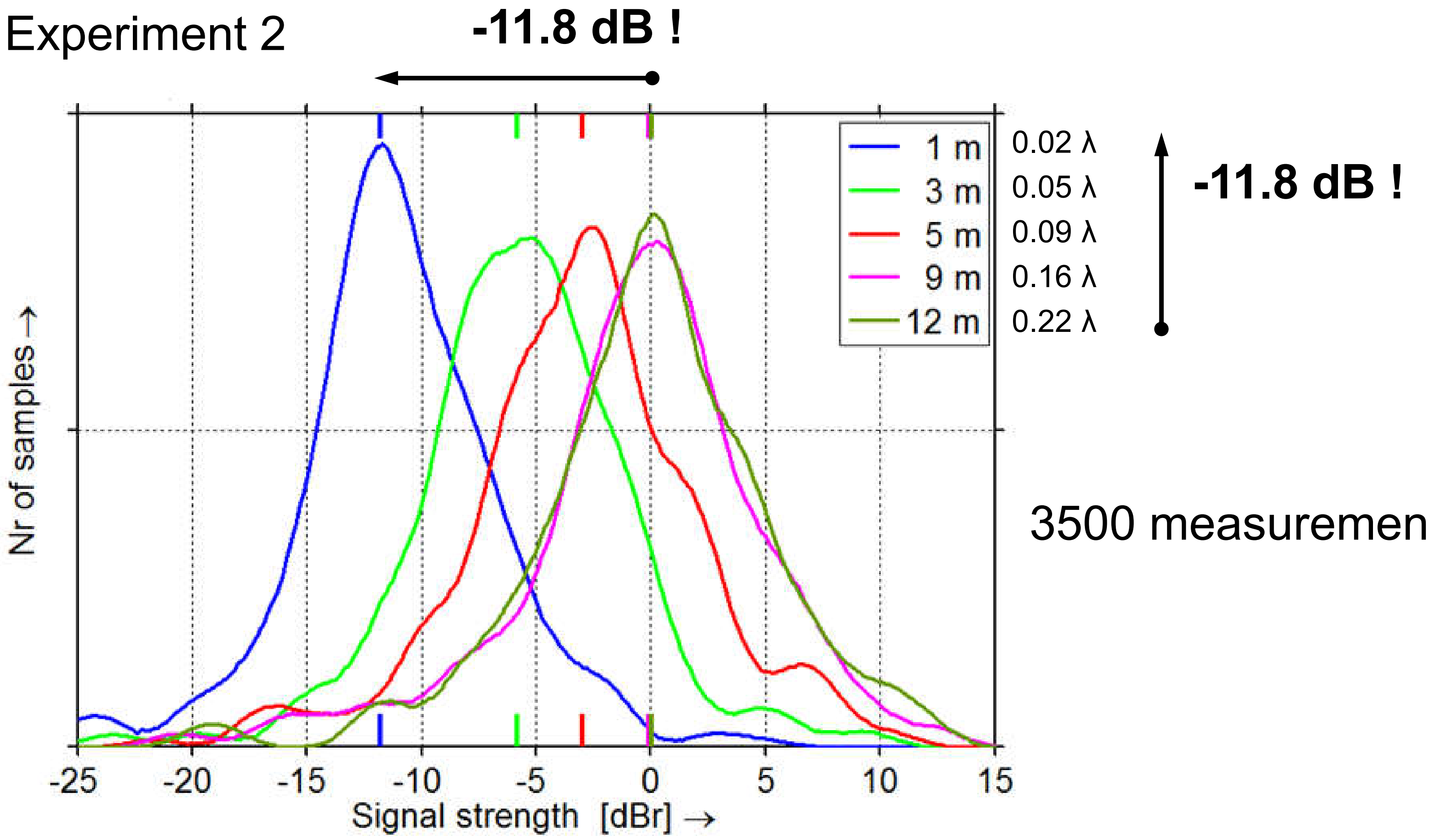
Experiment 1



3500 measurements

4. A practical experiment

Experiment 2



3500 measurements

4. A practical experiment

Antenna height		NVIS ANTENNA GAIN		
		Simulated	Meas.1	Meas.2
12.5 m	0.22 λ	-0.2 dBr	0.0 dBr	0.0 dBr
9 m	0.16 λ	-0.0 dBr	-0.8 dBr	0.0 dBr
5 m	0.09 λ	-1.5 dBr	-2.6 dBr	-3.0 dBr
3 m	0.05 λ	-5.0 dBr	-6.1 dBr	-5.8 dBr
1 m	0.02 λ	-12.0 dBr	-11.0 dBr	-11.8 dBr

-11 dB to
-12 dB !

Very good correspondence of theory and experiment!
Experiment confirms the NEC 4.1 simulations.

5. What's the difference?

This "improved experiment" was conducted by 4 radio amateurs and 1 scientist / radio amateur

So what's the difference?

- Thorough preparation
- Control of as many unwanted variables as possible
- Low measurement uncertainty
- Precise description, peer review, scientific publication [1]

[1] Witvliet, Ben A., et al. "Near Vertical Incidence Skywave propagation: Elevation angles and optimum antenna height for horizontal dipole antennas," IEEE Antennas and Propagation Magazine, 57.1 (2015): 129-146.

5. What's the difference?

What's can radio scientists offer radio amateurs?

- Encouragement
- Theoretical basis
- Advice on improvements of experiments ☺
- Feedback on flawed or incomplete work ☹
- Cooperation and joined publication

6. Your questions

Free publication download from

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

Contact information

dr. Ben A. Witvliet, email B.A.Witvliet@bath.ac.uk