mobilefish.com

LORA / LORAWAN TUTORIAL 43

Sleeve Dipole Antenna

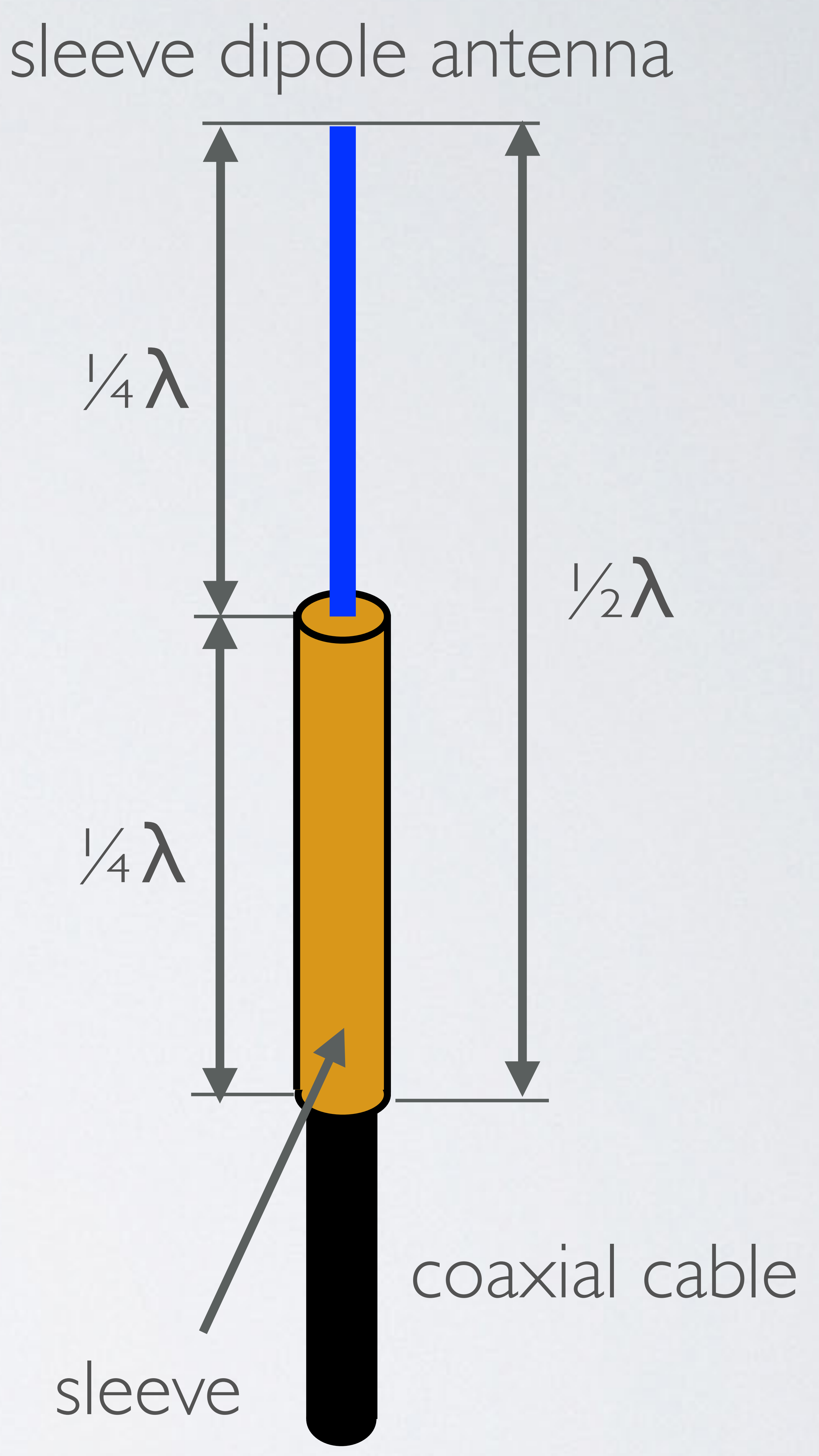
v1.1.0

INTRO

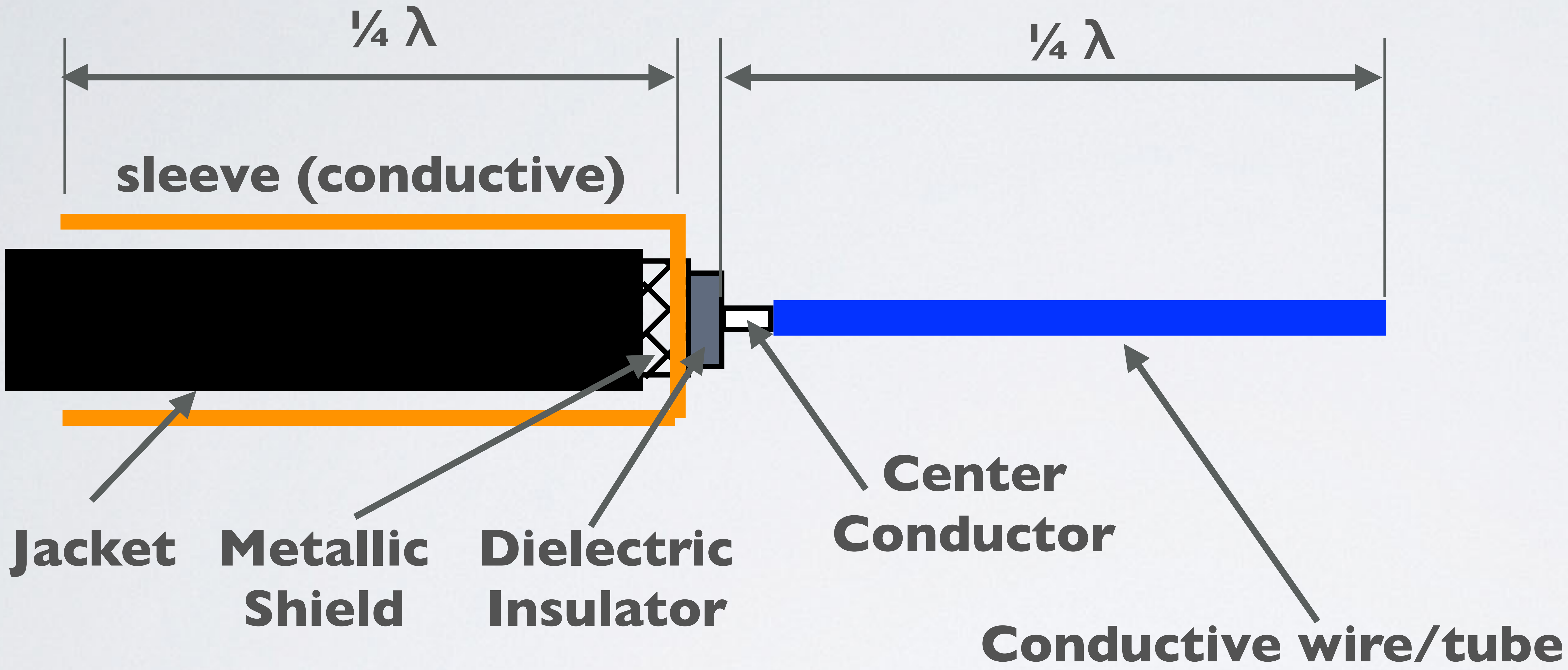
- In this tutorial I will explain what a sleeve dipole antenna is.

SLEEVE DIPOLE ANTENNA

- Just like a dipole antenna, a sleeve dipole antenna has two elements.
- One element is attached to the coax cable centre conductor.
- The other element which is a metal tube (sleeve) is around the coax cable. The sleeve is attached to the coax cable metallic shield.
- The sleeve dipole antenna is also know under several other names for example: vertical sleeve antenna and coaxial sleeve antenna.



SLEEVE DIPOLE ANTENNA

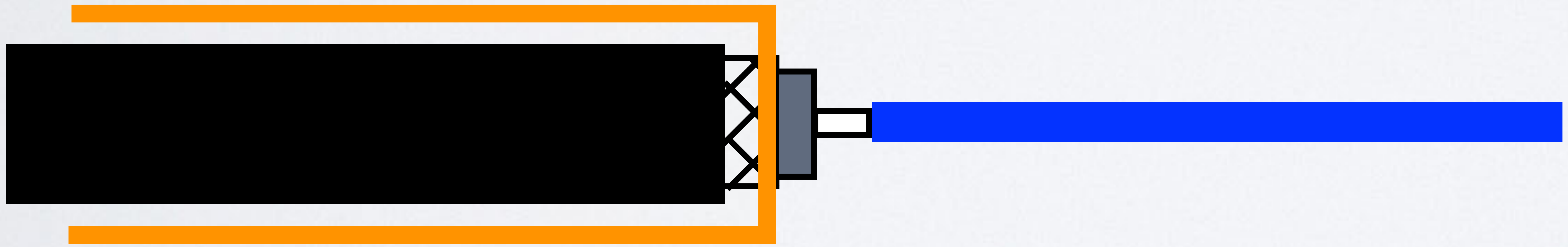


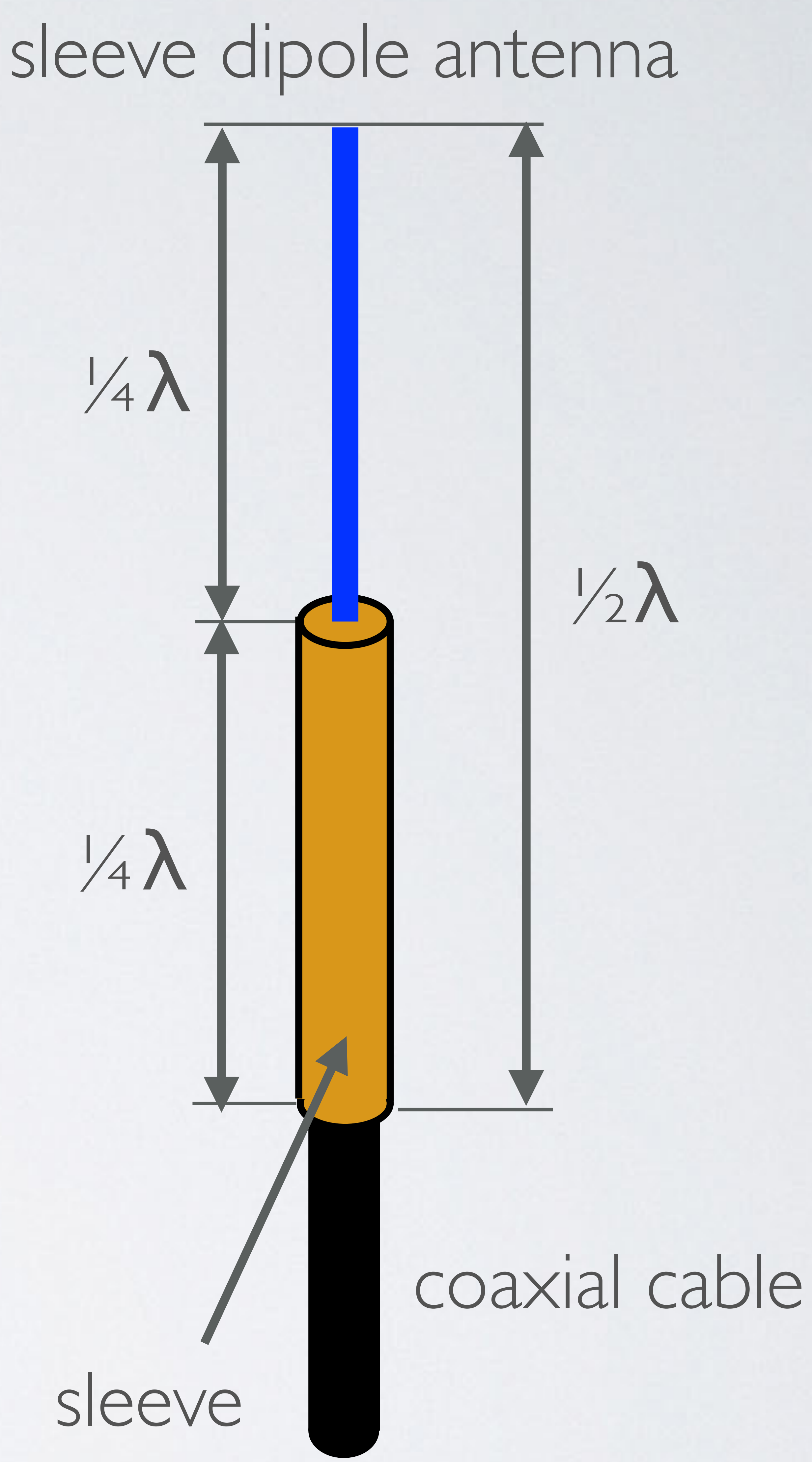
SLEEVE DIPOLE ANTENNA

- The sleeve dipole antenna is a balanced antenna just like an ordinary dipole antenna.

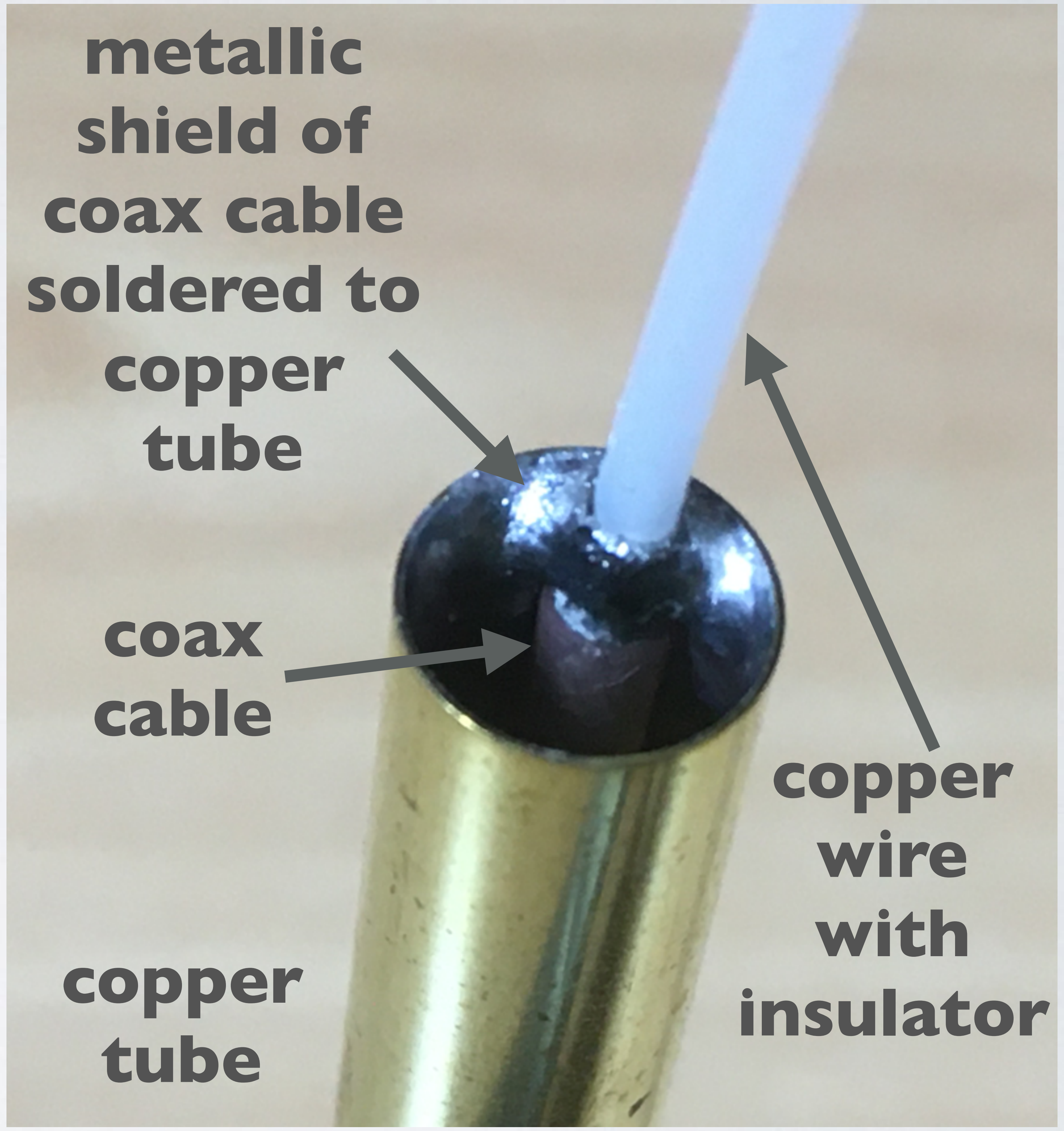
- The sleeve dipole antenna is fed by a coax cable which is an unbalanced feed line. Normally in such a case a balun is needed.

- In this case however the sleeve acts as a balun which counter the effects of the current returning back along the outer braid of the coax cable (antenna current).



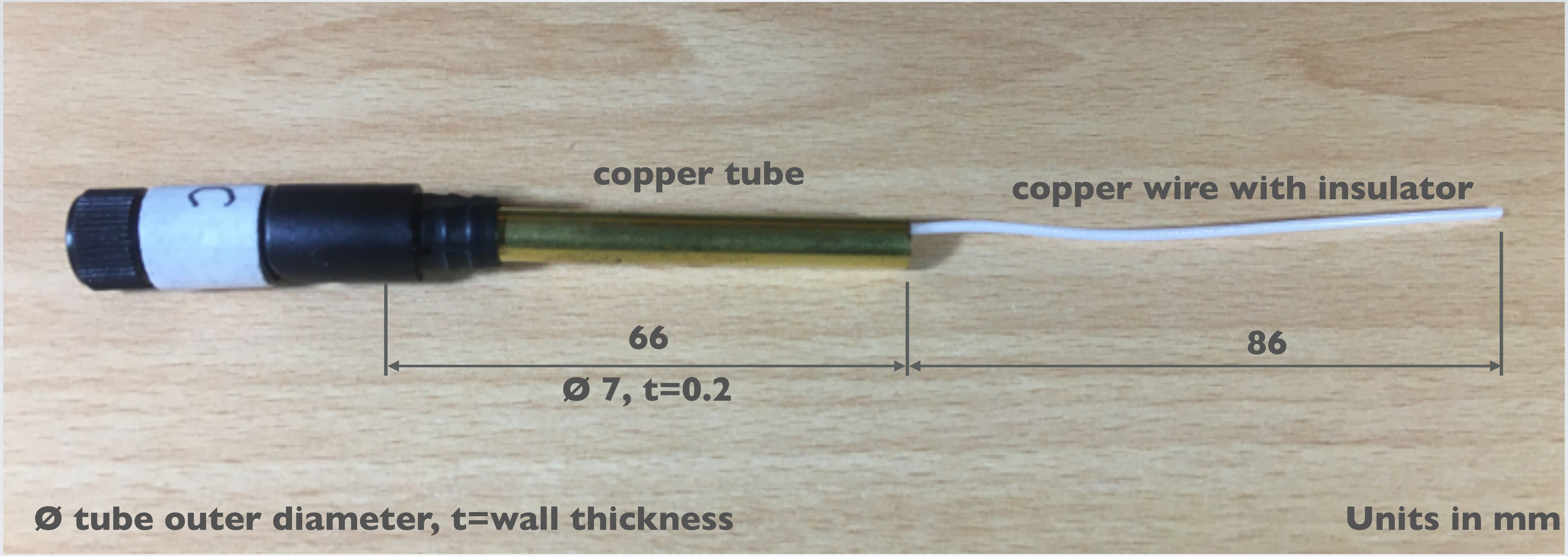


SLEEVE DIPOLE ANTENNA



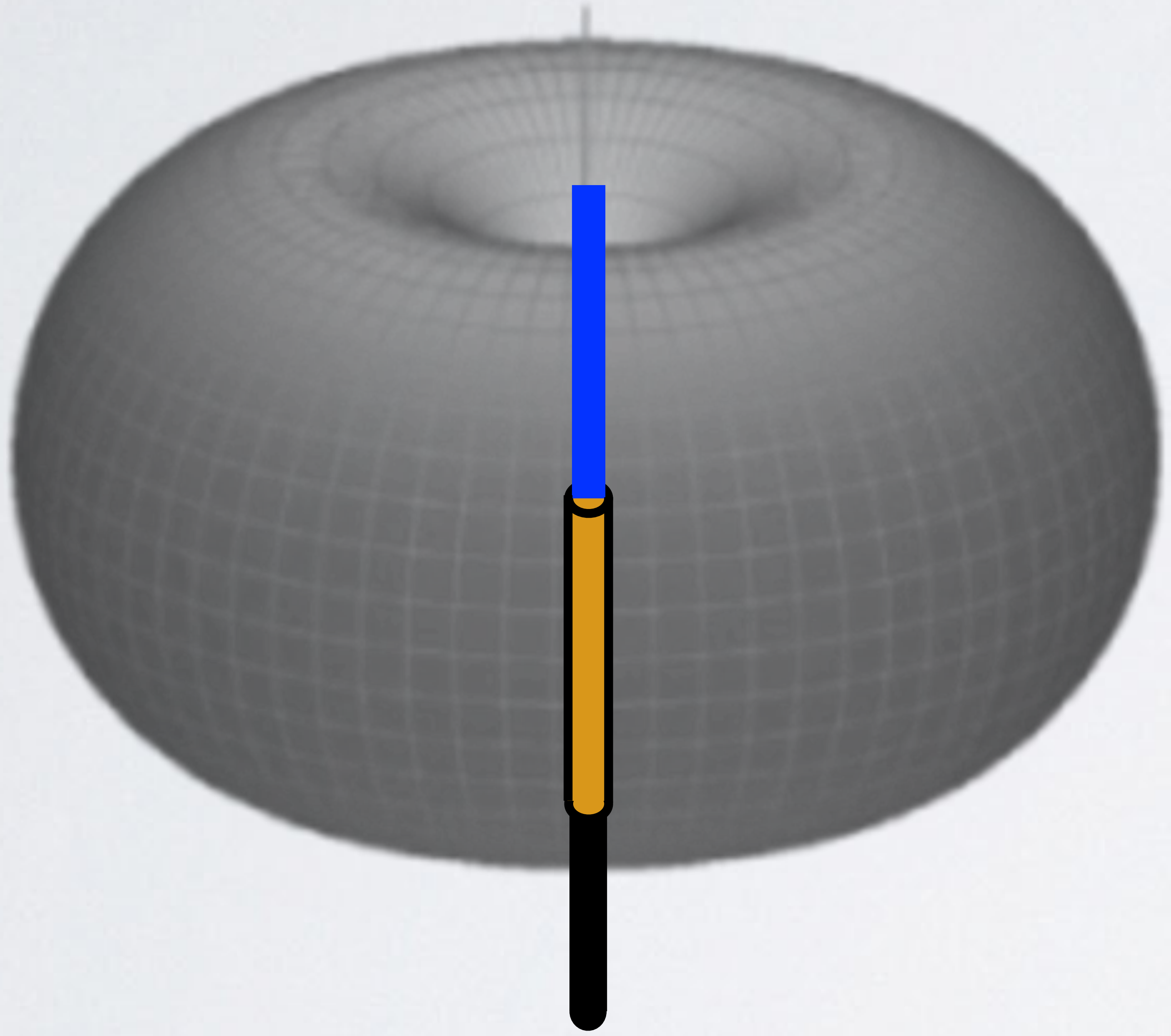
This is the sleeve dipole antenna C as discussed in tutorial 33.

SLEEVE DIPOLE ANTENNA



SLEEVE DIPOLE ANTENNA

- The sleeve dipole antenna has the same donut shape radiation pattern as the normal dipole antenna (in free space).



- A sleeve dipole antenna has a gain of 2.15 dBi (= 0 dBd)

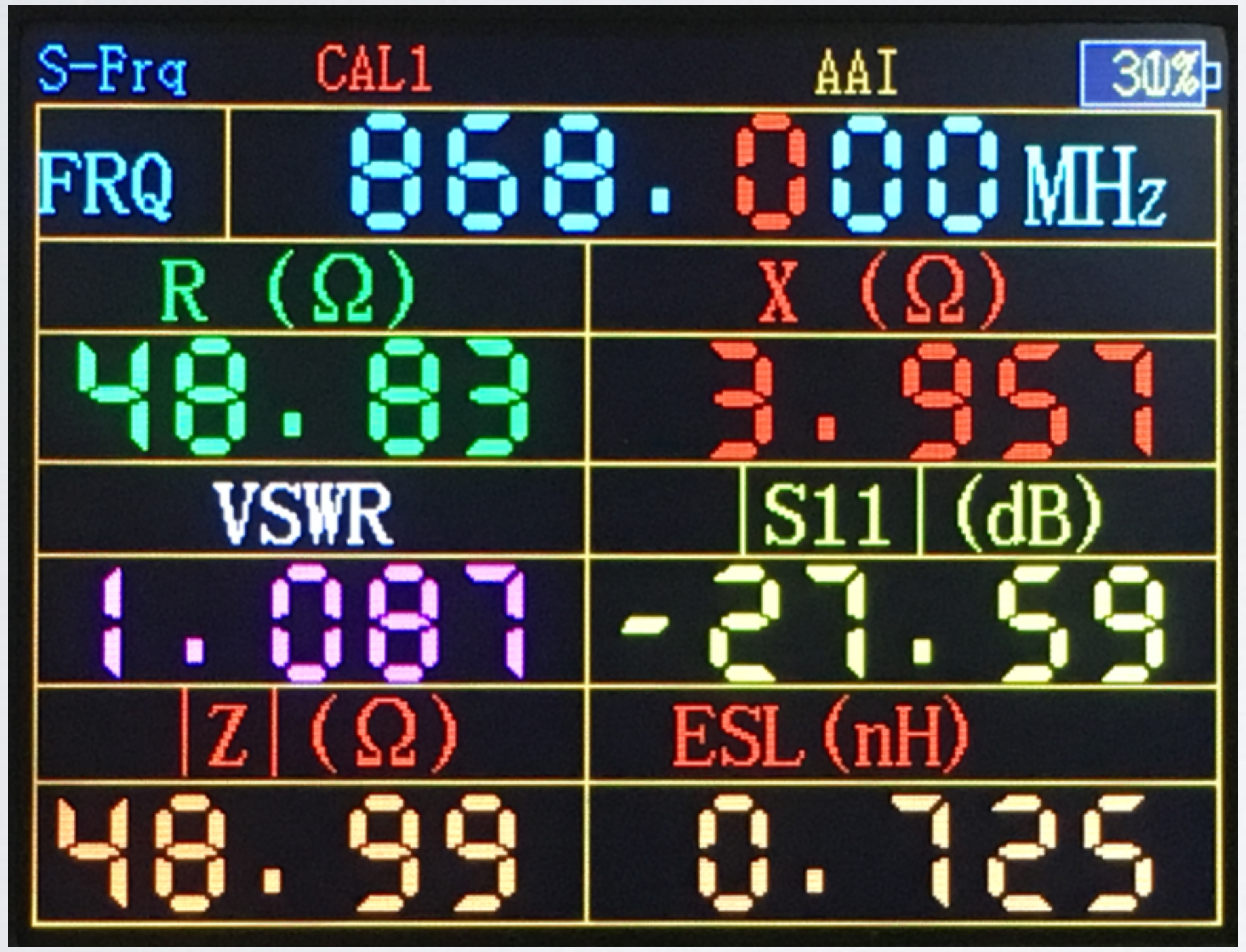
SLEEVE DIPOLE ANTENNA

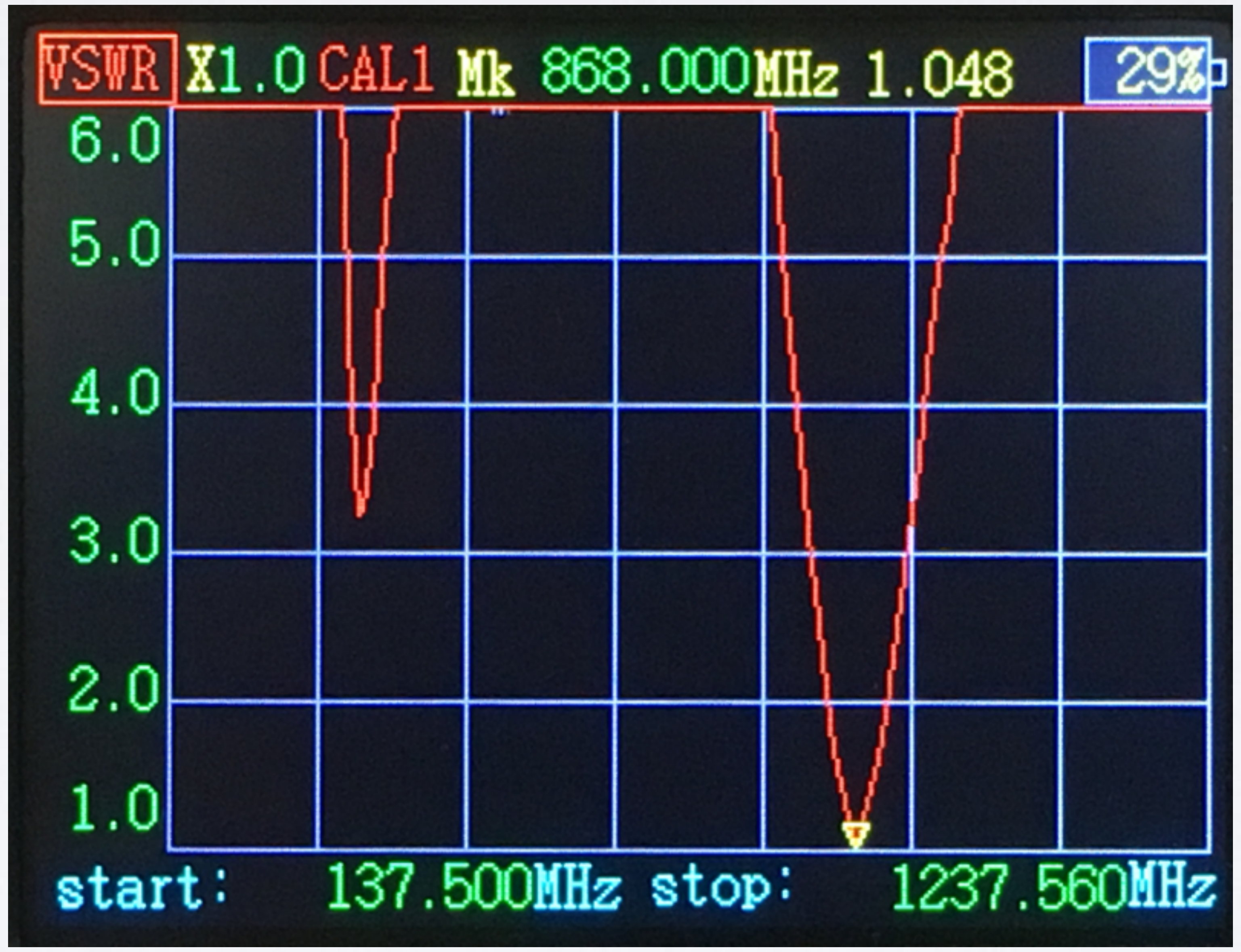
The antenna analyser with the sleeve dipole antenna C.

Antenna C is discussed in tutorial 33.

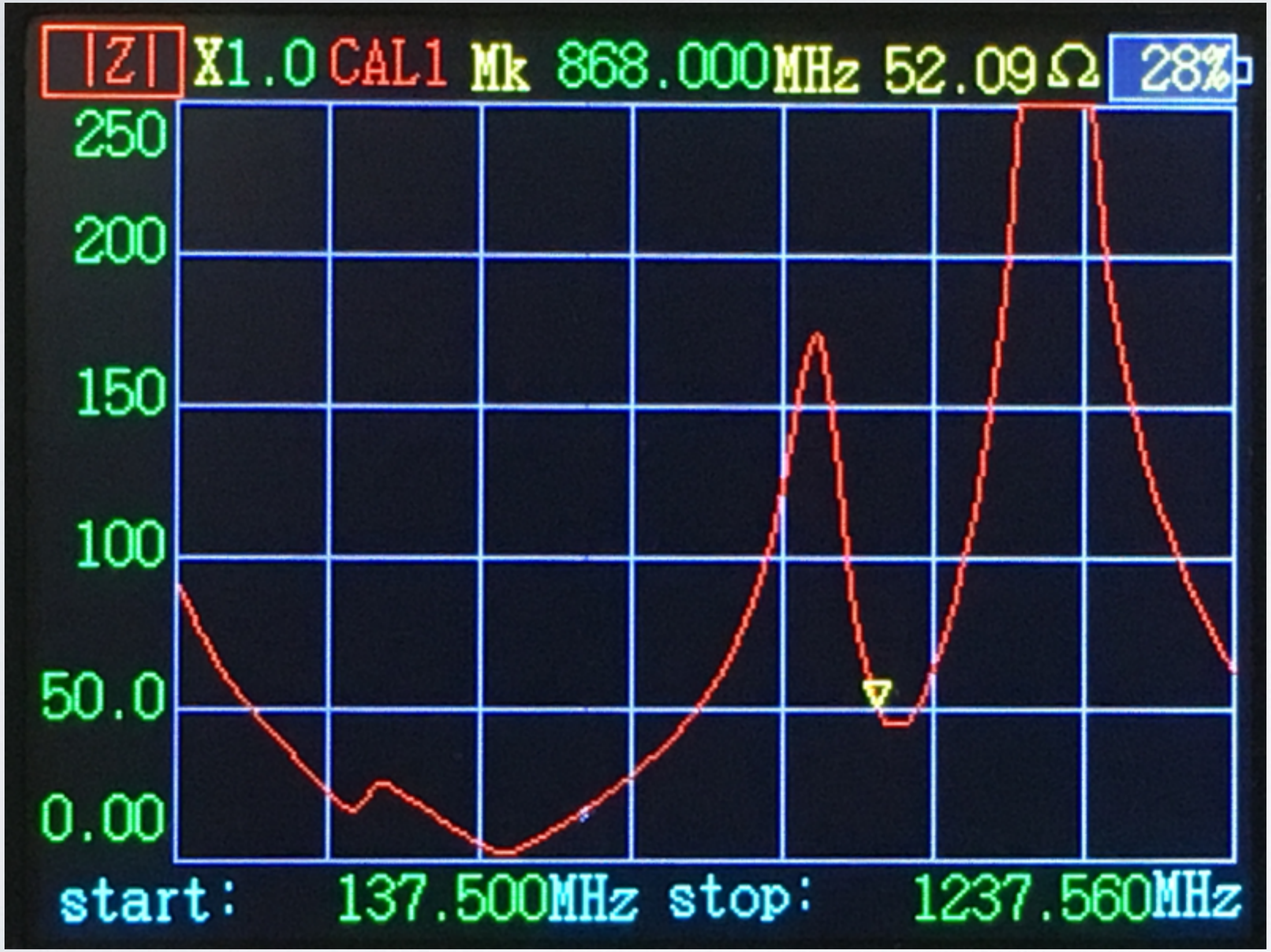
MEASURED ANTENNA PARAMETERS

- In **MY** situation I got the following results:
  VSWR ≈ 1.1 ⟵ Good. It is < 2
  Z ≈ 49Ω ⟵ Good. Should be approx. 50Ω
  S11 ≈ -28 dB





MEASURED ANTENNA PARAMETERS



ATTENTION

- When buying an antenna:
  Beware many antennas do not work as advertised!

- Use an antenna analyser, such as the N1201SA, to check the antenna (see tutorial 40).

SLEEVE DIPOLE ANTENNA

- A ***correctly*** advertised sleeve dipole antenna should look like this:

- Foldable omnidirectional antenna
  Gain: 2.15 dBi
  Standing wave ratio / VSWR: <=2.0
  Impedance: 50Ω
  Polarisation type: Vertical or Horizontal
  Housing Material: ABS
  Cable Connector: RP-SMA or SMA

SLEEVE DIPOLE ANTENNA

- There are sleeve dipole antennas which are tuned to work for both 868 MHz **and** 915 MHz. Here is one which is opened. It is antenna B mentioned in tutorial 33.

- Compared to single frequency tuned sleeve dipole antennas, these two frequencies tuned antennas costs slightly more and they have slightly higher VSWR values but the VSWR is still below 2.

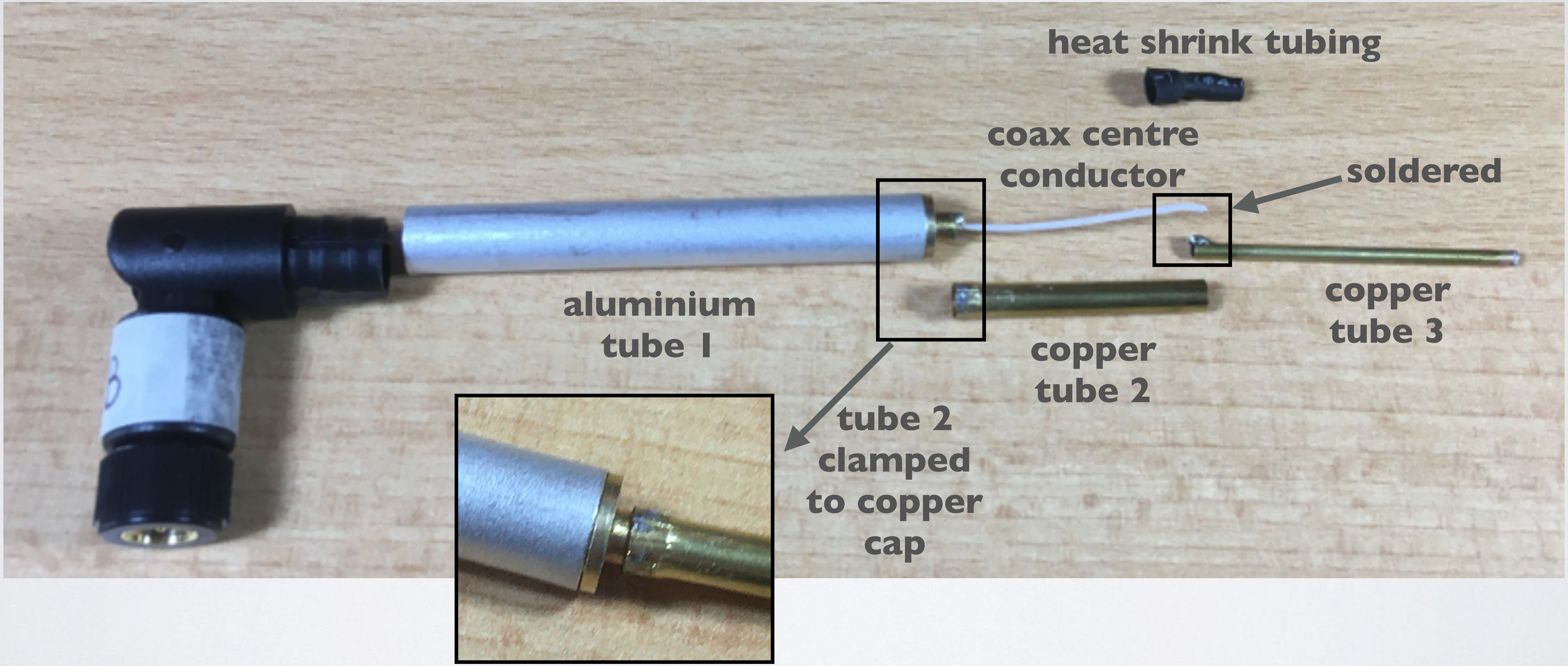
ANTENNA B

- I have been poking inside antenna B, which caused the VSWR to change to 2.4 as mentioned in tutorial 40.

- I was curious how this antenna was build, so I decided to disassemble it and tune it.

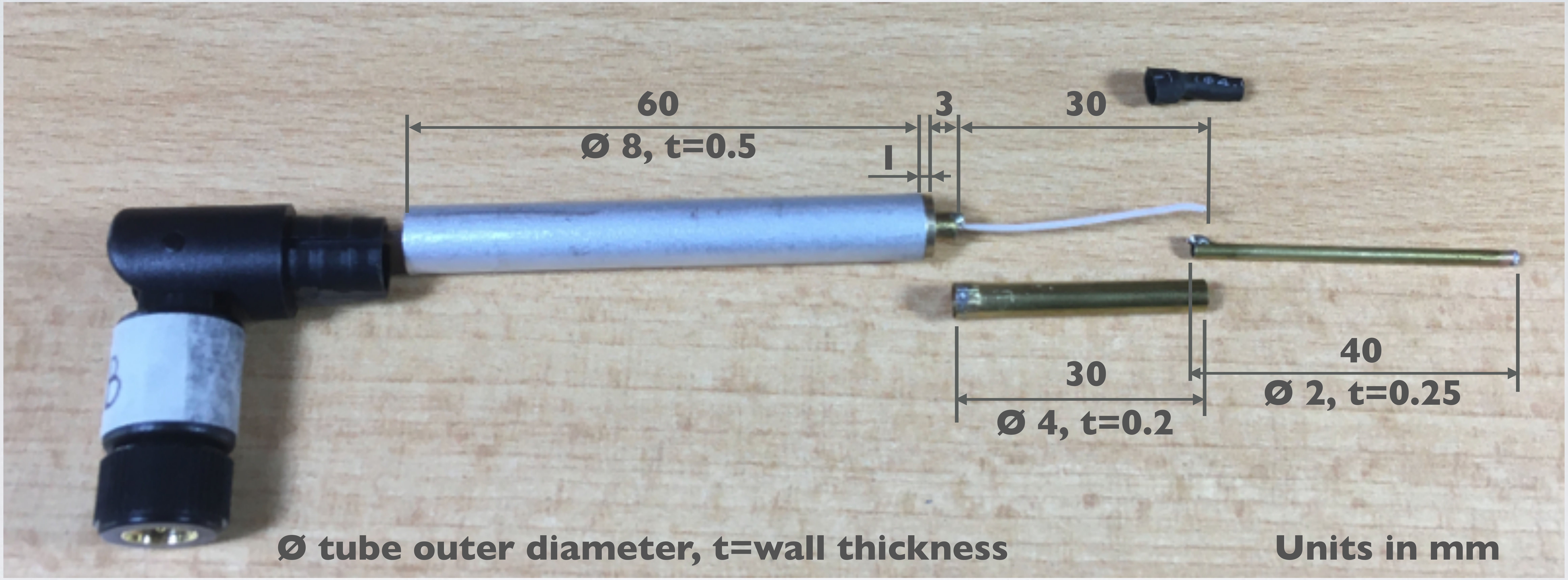
ANTENNA B

- Antenna B disassembled.



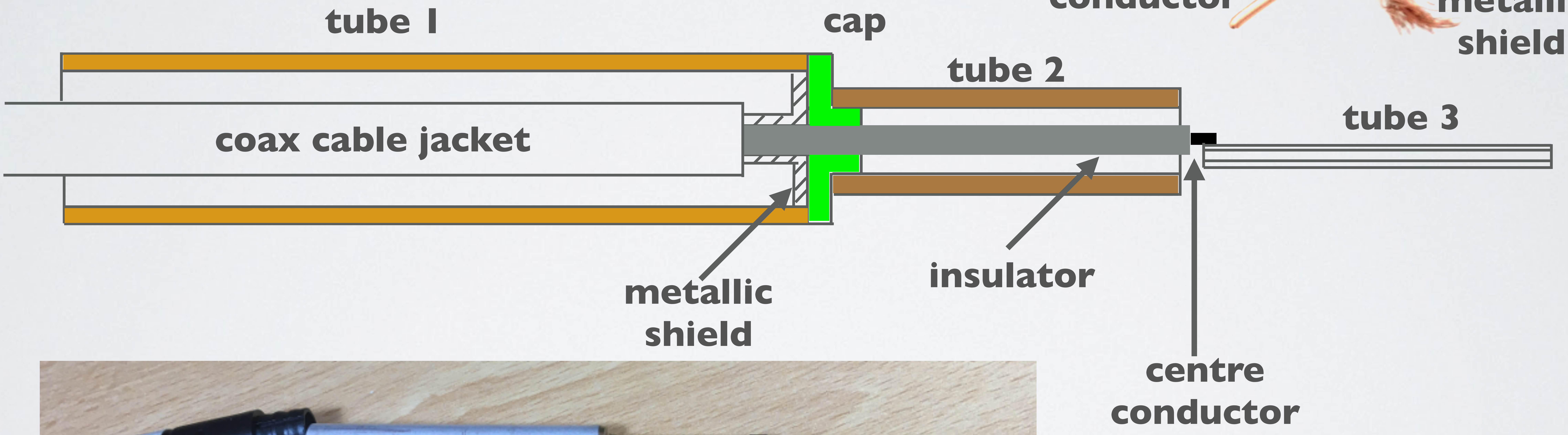
ANTENNA B

- Antenna B disassembled.



ANTENNA B

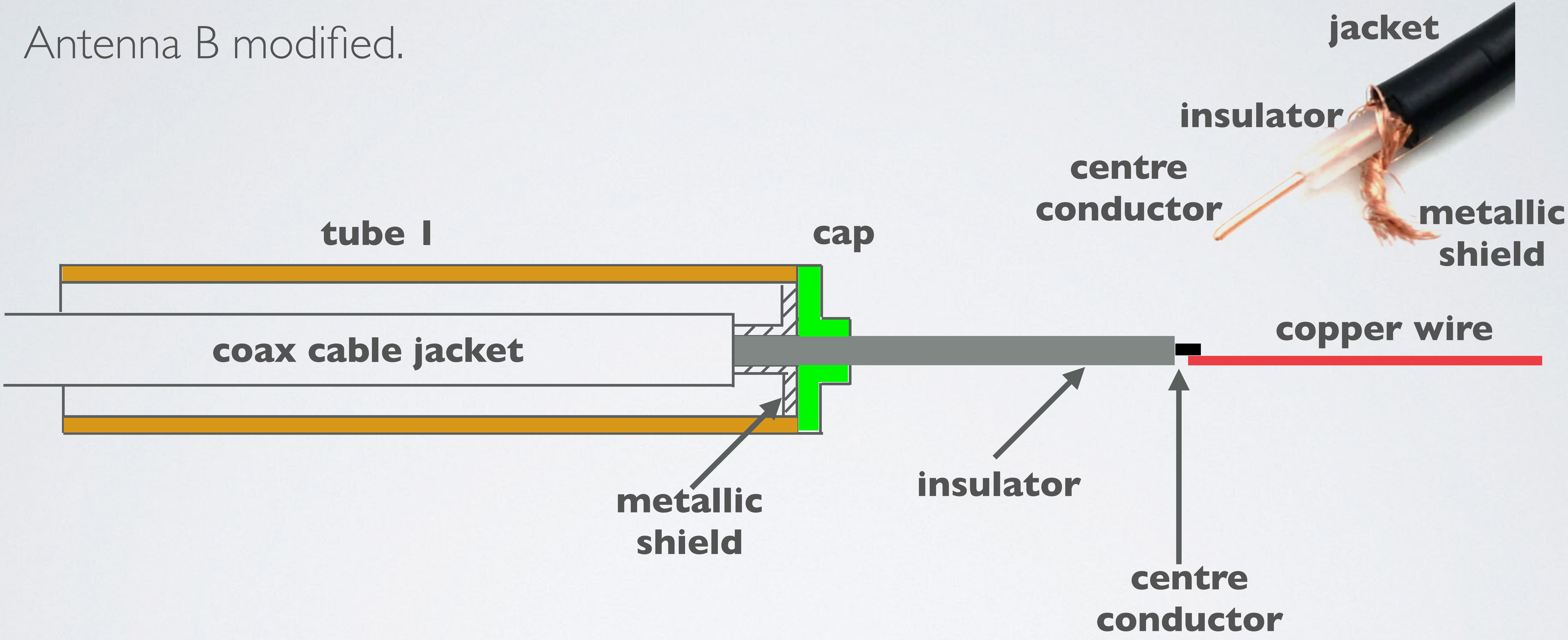
- I am not an antenna engineer, but I question whether this is a good antenna.🤔



Drawing not to scale

ANTENNA B

- Antenna B modified.



Drawing not to scale

ANTENNA B

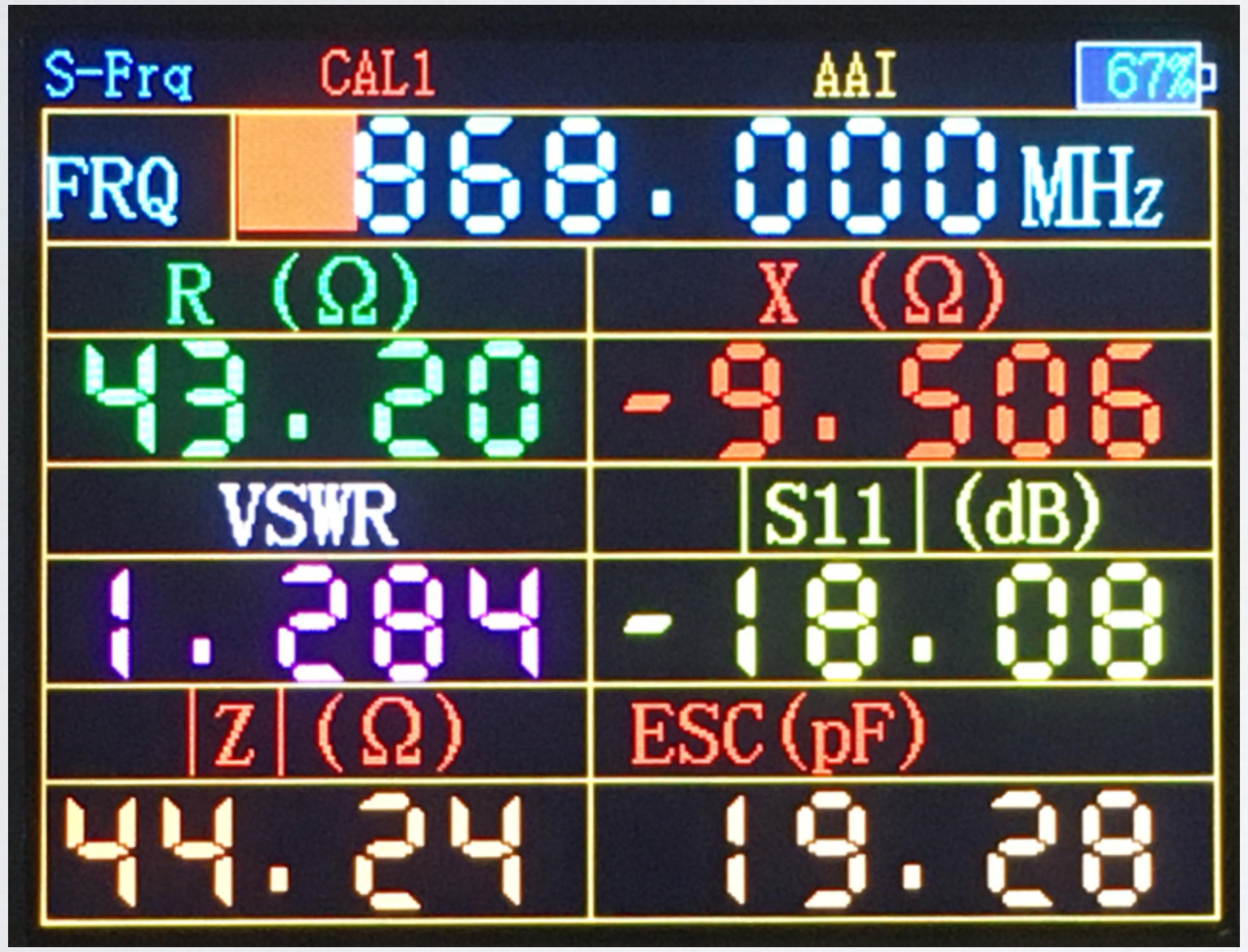
- Antenna B **only** optimised for frequency 868 MHz

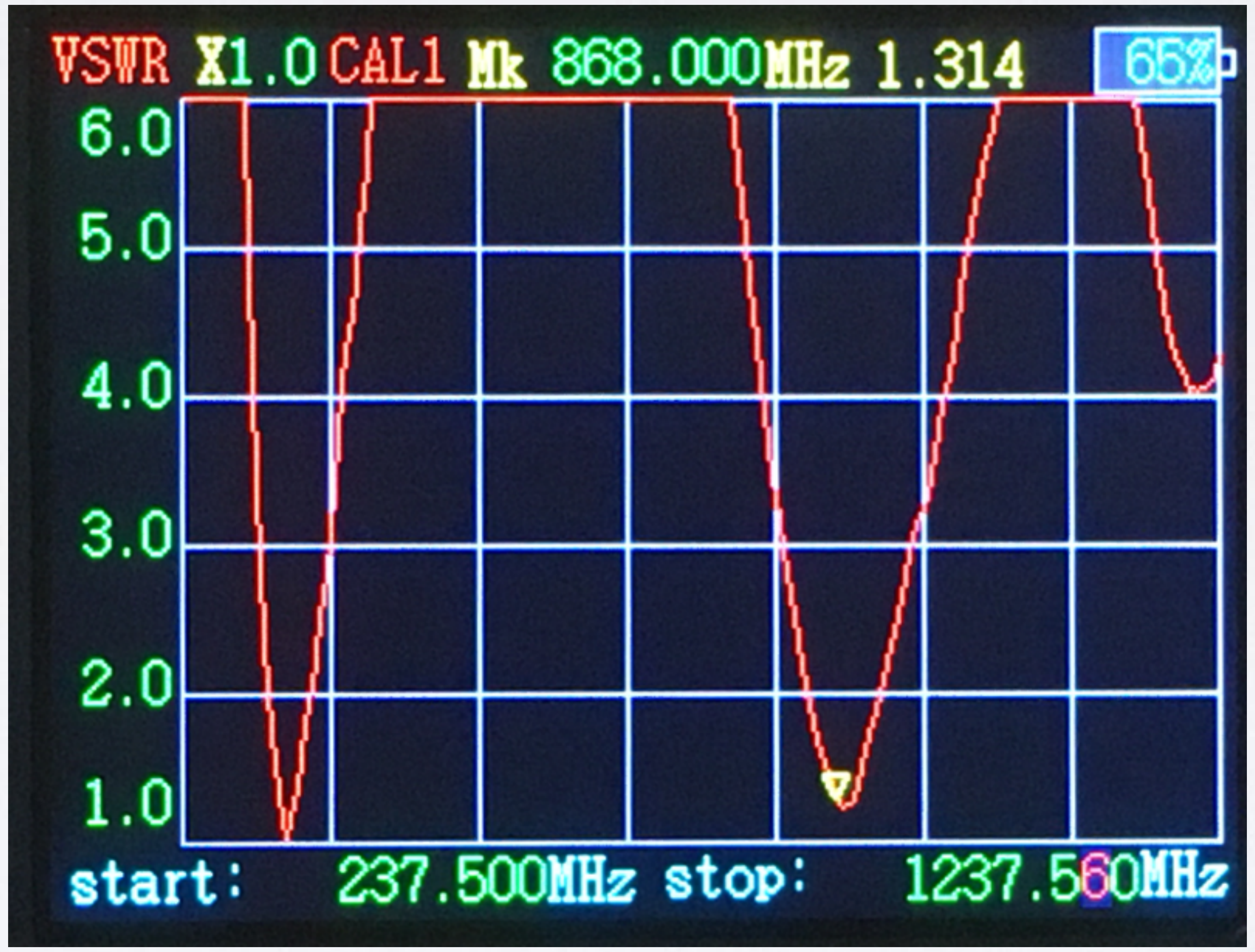
ANTENNA B

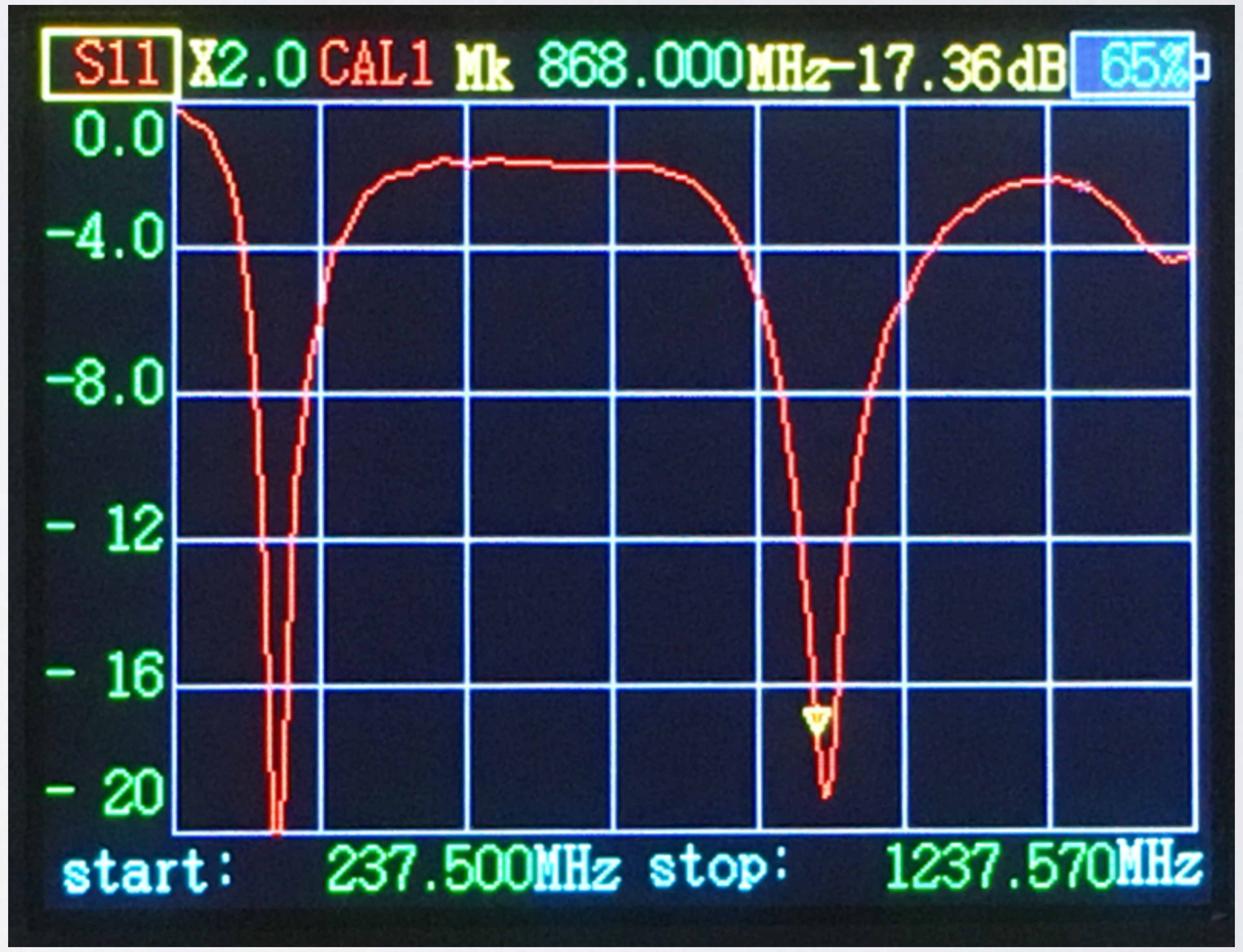
The antenna analyser with the modified sleeve dipole antenna B, optimised for 868 MHz.

MEASURED ANTENNA PARAMETERS

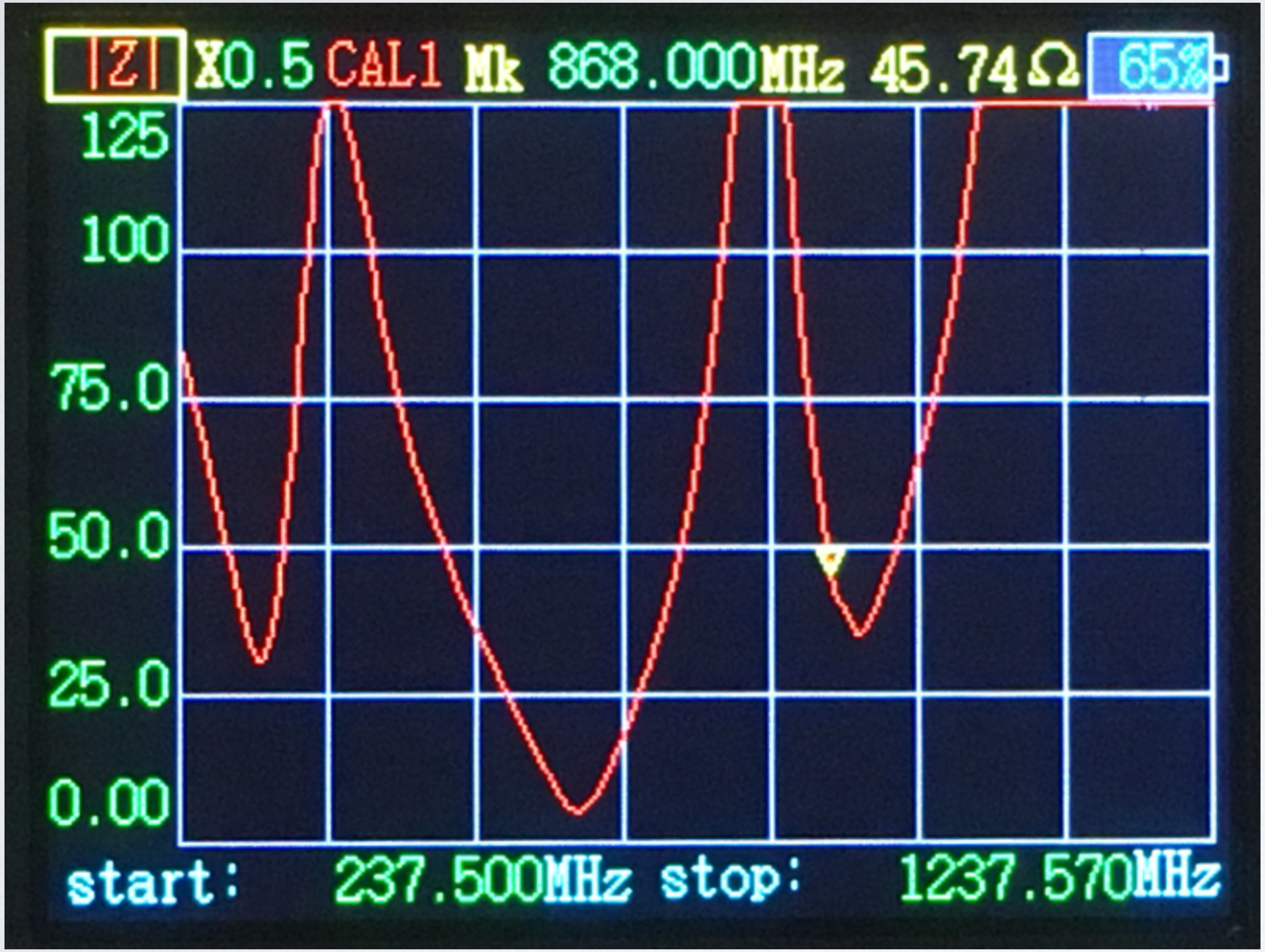
- In **MY** situation I got the following results:
  VSWR ≈ 1.3 ⟵ Good. It is < 2
  Z ≈ 44Ω ⟵ Good. Should be approx. 50Ω
  S11 ≈ -18 dB







MEASURED ANTENNA PARAMETERS



ANTENNA TEST SETUP

- The modified sleeve dipole antenna B performance is compared with sleeve dipole antenna C.

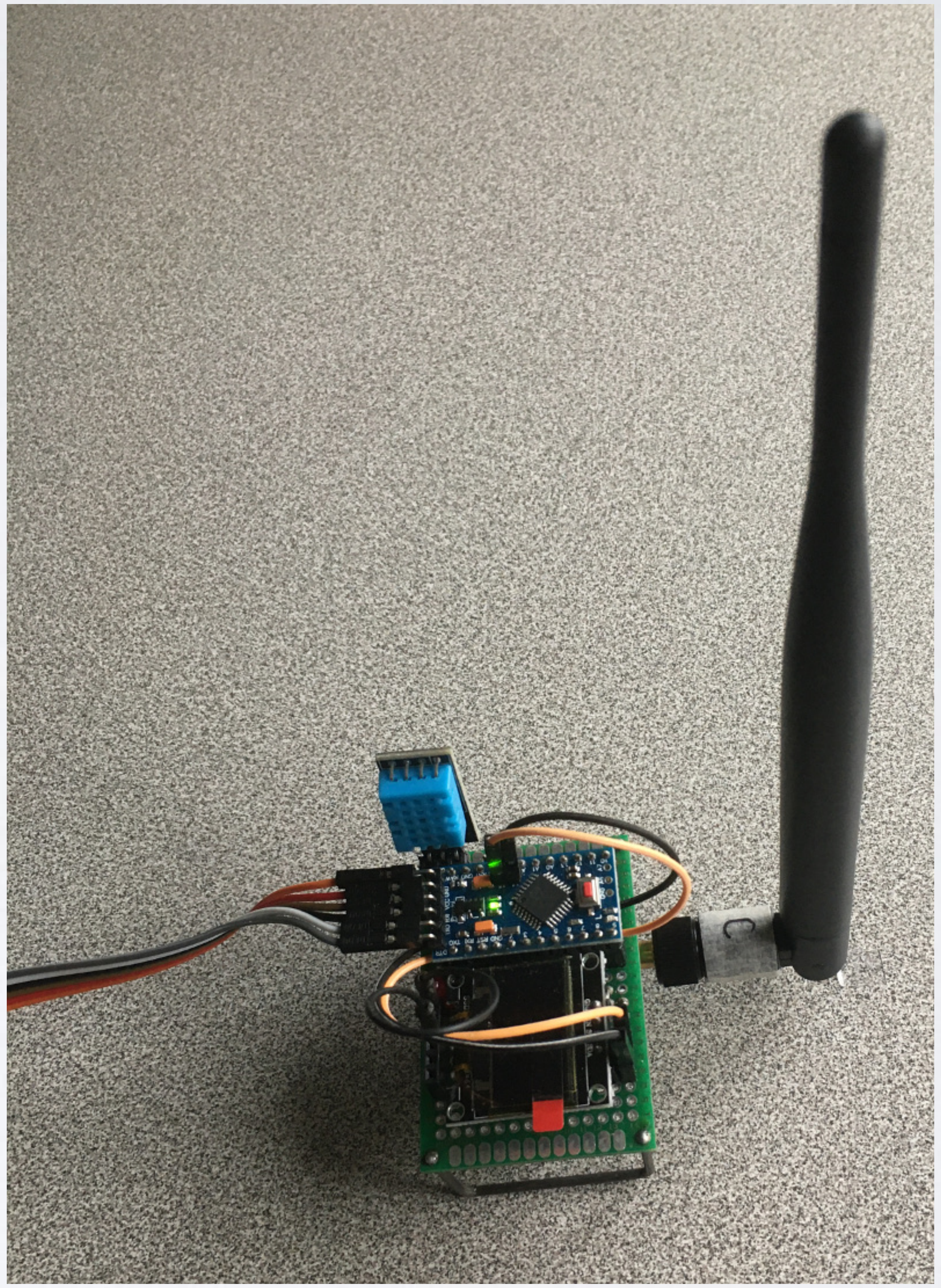
- More information about this end node, see: https://www.mobilefish.com/developer/lorawan/lorawan_quickguide_build_lora_node_rfm95_arduino_pro_mini.html

- The end node uses the MCCI LoRaWAN LMIC Library: https://github.com/mcci-catena/arduino-lmic

- The end node uses the following sketch: https://www.mobilefish.com/download/lora/ttn-otaa-pro-mini-sensors.ino.txt

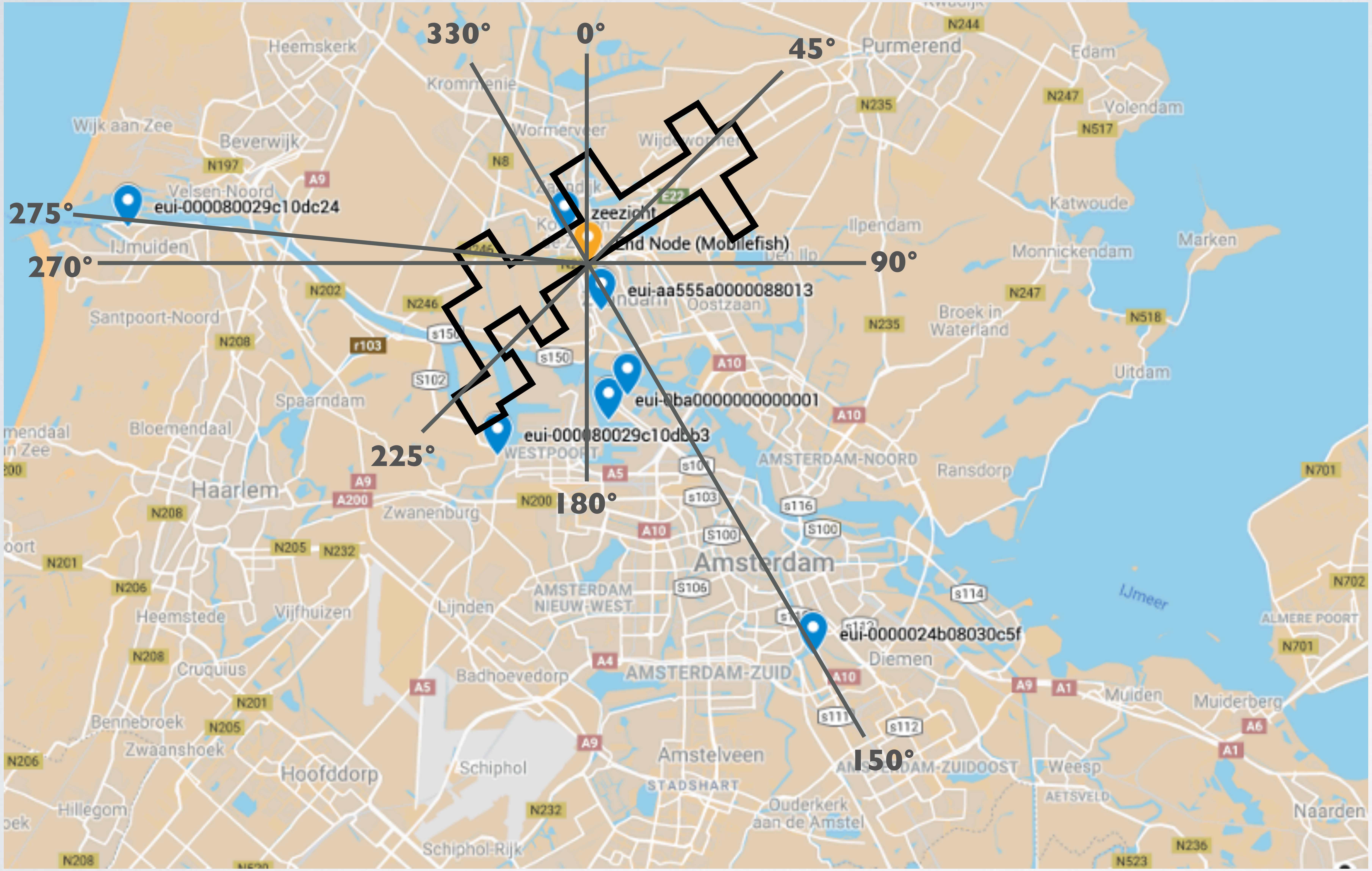
ANTENNA TEST SETUP

Modified sleeve dipole antenna B



Sleeve dipole antenna C

ANTENNA TEST SETUP



The building circumference.

The end node is placed inside the building in front of a window.

Two end node locations:

Location A, facing East and South. Altitude = ~11m

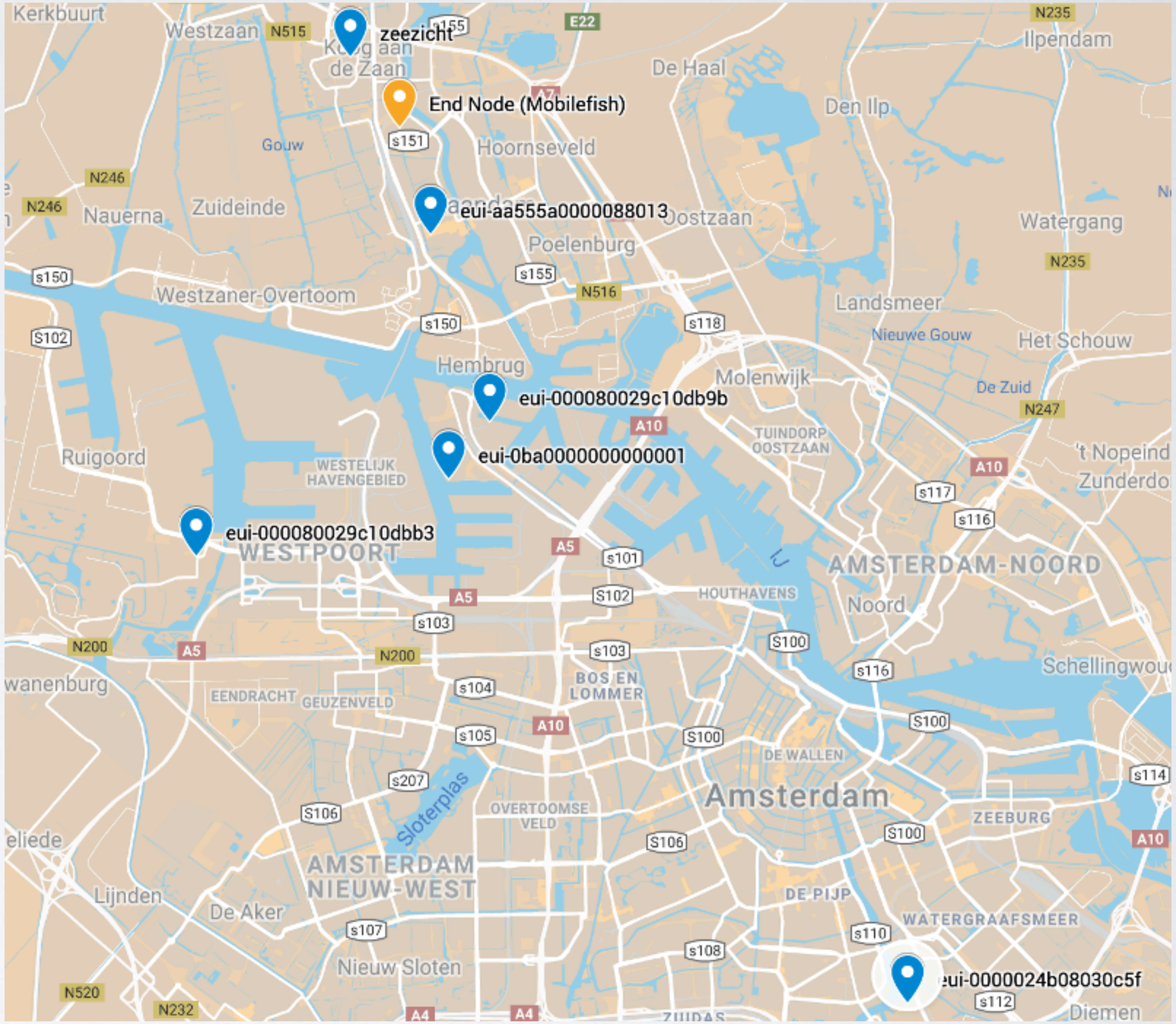
Location B, facing West and North. Altitude = ~11m

ANTENNA TEST SETUP

- I have NOT modified the end node transmission power when using both sleeve dipole antennas.
- Both sleeve dipole antennas were positioned at location A and in both cases two messages per minute were transmitted.
- The logged data can be found at: https://www.mobilefish.com/download/lora/sleeve_dipole_comparison.txt

ANTENNA TEST RESULTS

- One or more gateways were able to receive my transmitted sensor data, see: https://drive.google.com/open?id=18SKbHVEIFHU6YjzYpgZL98vuHcmV4OPQ&usp=sharing



ANTENNA TEST RESULTS

- End node tx power = 14 dBm
  Data from: sleeve_dipole_comparison.txt

Gateway	Distance from end device [km]	Altitude [m]	Modified sleeve dipole B Average RSSI [dBm]	Sleeve dipole C Average RSSI [dBm]
eui-aa555a0000088013	1.57	42	-117 *	-119 *
eui-000080029c10dc24	14.7	45	-120 *	-120 *
eui-000080029c10db9b	4.36	30	-117.2 *	-119 *
eui-0ba0000000000001	5.02	20	**-118.4**	**- 119.1**
eui-60c5a8fffe760e60	4.15	30	-113.6 *	-115 *
eui-dca632fffe43df3e	0.458	10	**-106**	**-106.3**
eui-b827ebfffedcc77d	0.816	7	-113 *	-115 *
eui-000080029c10dbb3	6.73	5	-120 *	-
eui-0000024b08030c5f	1.57	40	-	-119 *

* Only one or few measurements. I will ignore these results.

ANTENNA TEST RESULTS

- If you only look at the results you may notice there is no significant difference in the average RSSI values.

- When using the modified antenna B it took 9 minutes to receive 15 messages.
  When using antenna C, which is my reference antenna, it took 11.5 minutes to receive 15 messages.

- This difference is caused by the limited number of measurements.
  Once more measurements were taken there was no significant difference in time.

- The Arduino sketch is configured to transmit 2 messages per minute. In a perfect situation it should take 7.5 to 8 minutes to receive these 15 messages.

ANTENNA TEST RESULTS

	time	counter	port								
▲	10:10:36	16	1	dev id:	youtube_demo_device	payload:	0A 8C 05 78	humidity:	27	temperature:	14
▲	10:09:58	15	1	dev id:	youtube_demo_device	payload:	0A 8C 05 78	humidity:	27	temperature:	14
▲	10:09:22	14	1	dev id:	youtube_demo_device	payload:	0A 8C 05 78	humidity:	27	temperature:	14
▲	10:08:45	13	1	dev id:	youtube_demo_device	payload:	0A 8C 05 78	humidity:	27	temperature:	14
▲	10:07:33	11	1	dev id:	youtube_demo_device	payload:	0A 8C 05 78	humidity:	27	temperature:	14
▲	10:06:56	10	1	dev id:	youtube_demo_device	payload:	0A 8C 05 78	humidity:	27	temperature:	14
▲	10:06:20	9	1	dev id:	youtube_demo_device	payload:	0A 8C 05 78	humidity:	27	temperature:	14
▲	10:05:44	8	1	dev id:	youtube_demo_device	payload:	0A 8C 05 78	humidity:	27	temperature:	14
▲	10:05:07	7	1	dev id:	youtube_demo_device	payload:	0A 8C 05 78	humidity:	27	temperature:	14
▲	10:04:30	6	1	dev id:	youtube_demo_device	payload:	0A 8C 05 78	humidity:	27	temperature:	14
▲	10:03:54	5	1	dev id:	youtube_demo_device	payload:	0A 8C 05 78	humidity:	27	temperature:	14

Modified sleeve dipole antenna B.

ANTENNA TEST RESULTS

	time	counter	port				
▲	10:38:26	19	1	dev id: youtube_demo_device	payload: 0A 28 05 DC	humidity: 26	temperature: 15
▲	10:37:50	18	1	dev id: youtube_demo_device	payload: 09 C4 05 DC	humidity: 25	temperature: 15
▲	10:37:12	17	1	dev id: youtube_demo_device	payload: 0A 28 05 DC	humidity: 26	temperature: 15
▲	10:36:36	16	1	dev id: youtube_demo_device	payload: 09 C4 05 DC	humidity: 25	temperature: 15
▲	10:35:58	15	1	dev id: youtube_demo_device	payload: 0A 28 05 DC	humidity: 26	temperature: 15
▲	10:35:21	14	1	dev id: youtube_demo_device	payload: 0A 28 05 DC	humidity: 26	temperature: 15
▲	10:34:44	13	1	dev id: youtube_demo_device	payload: 0A 28 05 DC	humidity: 26	temperature: 15
▲	10:34:08	12	1	dev id: youtube_demo_device	payload: 0A 28 05 DC	humidity: 26	temperature: 15
▲	10:33:32	11	1	dev id: youtube_demo_device	payload: 0A 28 05 DC	humidity: 26	temperature: 15
▲	10:32:56	10	1	dev id: youtube_demo_device	payload: 0A 28 05 DC	humidity: 26	temperature: 15
▲	10:32:20	9	1	dev id: youtube_demo_device	payload: 0A 28 05 DC	humidity: 26	temperature: 15

Sleeve dipole antenna C.

ANTENNA TEST RESULTS

- Looking at the results I can conclude that both sleeve dipole antennas performs the same.

REMARKS

- If possible connect the antenna directly to the end node without the use of a coax cable. Each connector/cable used is additional loss.

- Watch out! An antenna which looks like this does not necessarily mean it is a sleeve dipole antenna.

- A nice Youtube tutorial how to build your own sleeve dipole antenna see: https://youtu.be/hK0KX0YcvH0

REMARKS

- You get different results when the sleeve dipole antenna is folded or not. Measure the antenna parameters in both states.

Modified antenna B

Unfolded
VSWR ≈ 1.2
Z ≈ 45Ω
S11 ≈ -18 dB

Folded
VSWR ≈ 1.7
Z ≈ 48Ω
S11 ≈ -12 dB

SLEEVE DIPOLE & 4NEC2

- I have modelled antenna B in 4NEC2.

- See: https://www.mobilefish.com/download/lora/sleeve_dipole.nec.txt

- The modelled antenna has a VSWR > 2 and I was not able to use the optimise functionality.

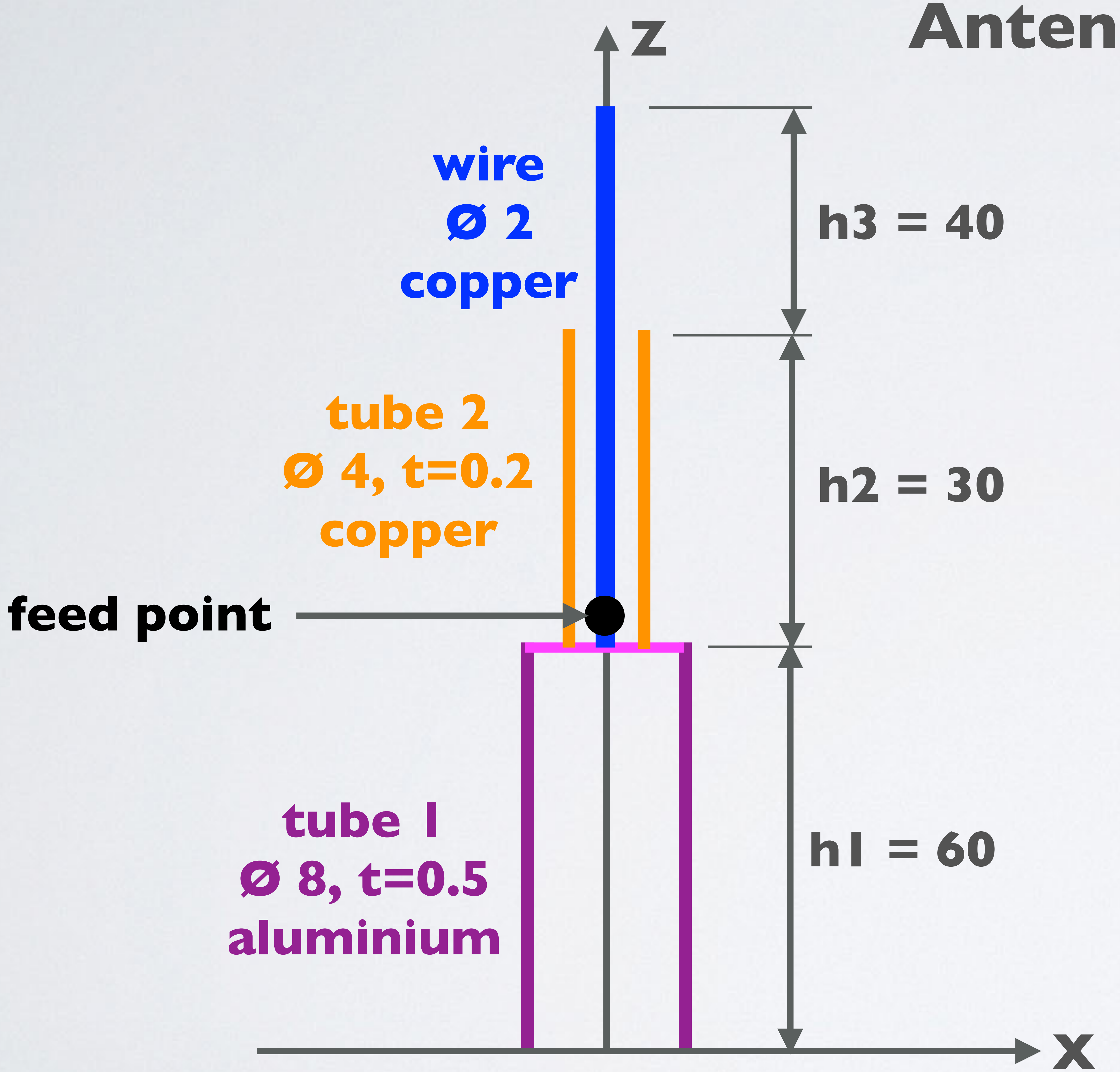
- **THE ANTENNA IS PROBABLY NOT CORRECTLY MODELLED.**

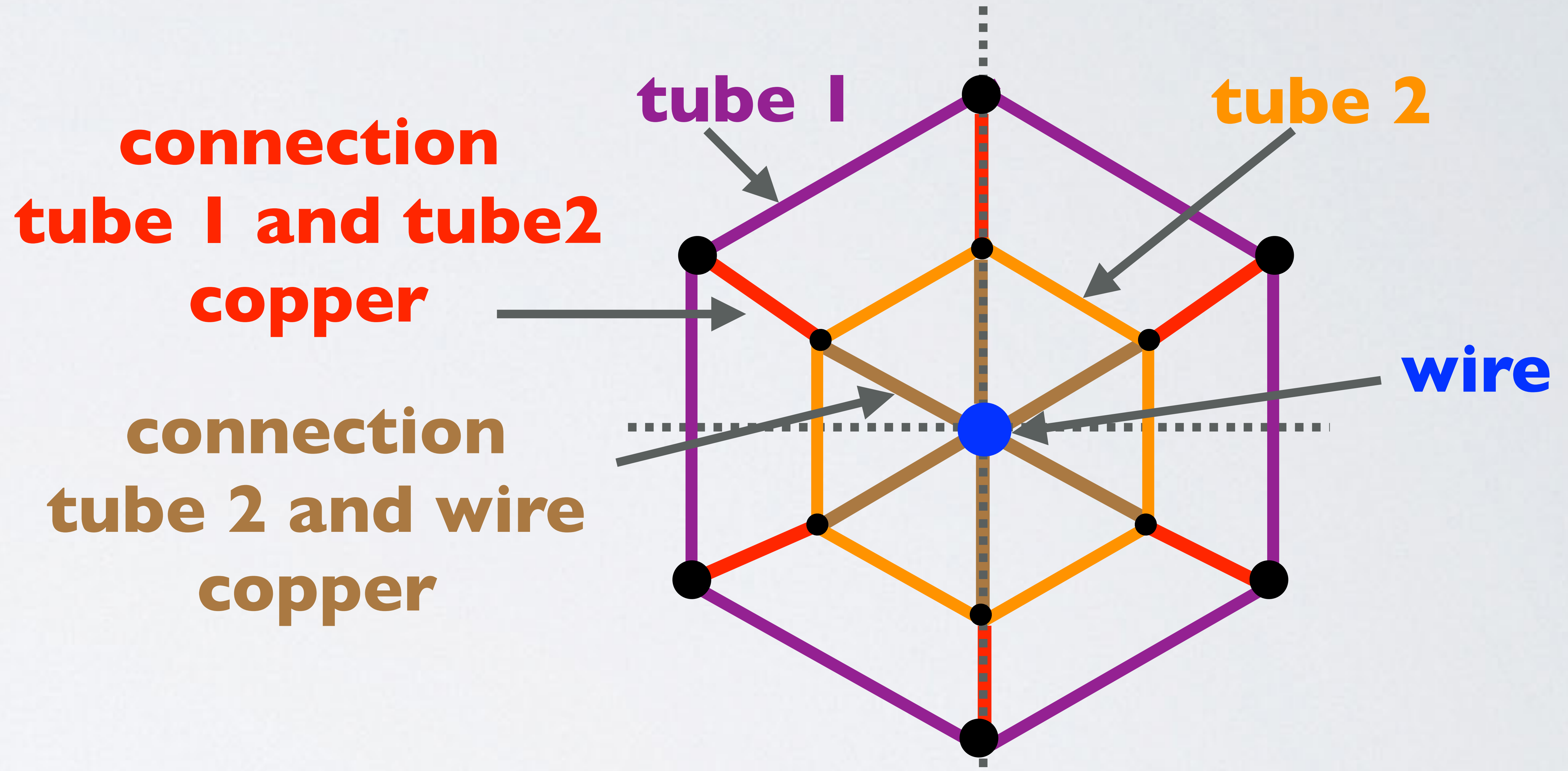
SLEEVE DIPOLE & 4NEC2

- Instead of throwing this antenna model away, I will keep it in case someone wants to use it and improve it.

SLEEVE DIPOLE & 4NEC2

Antenna B modelled in 4NEC2





Units in mm
Drawing not to scale