Fibre Sensing and NRENs

Dónal Cunningham, Asiera

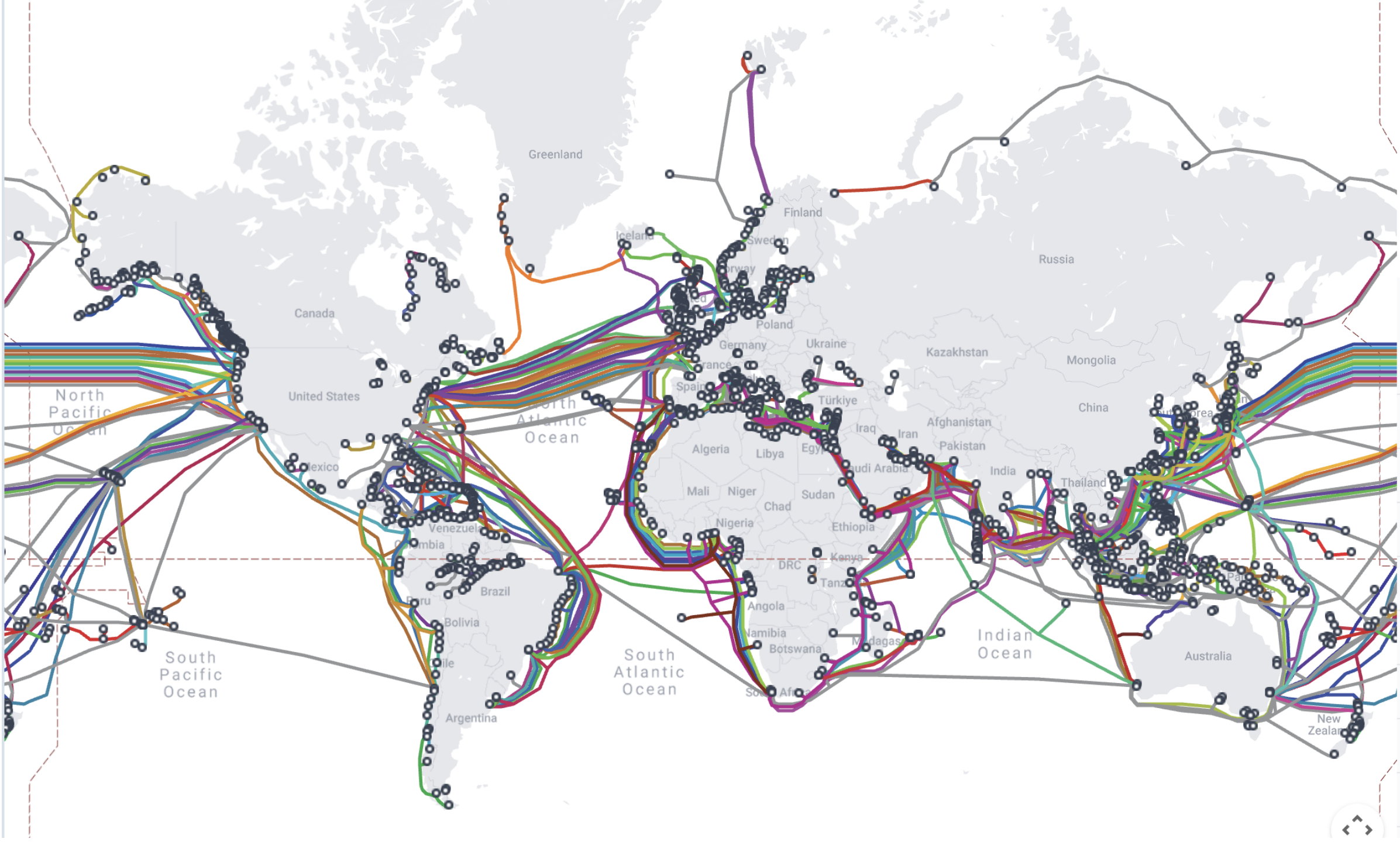
Fibre Sensing Training, Network eAcademy

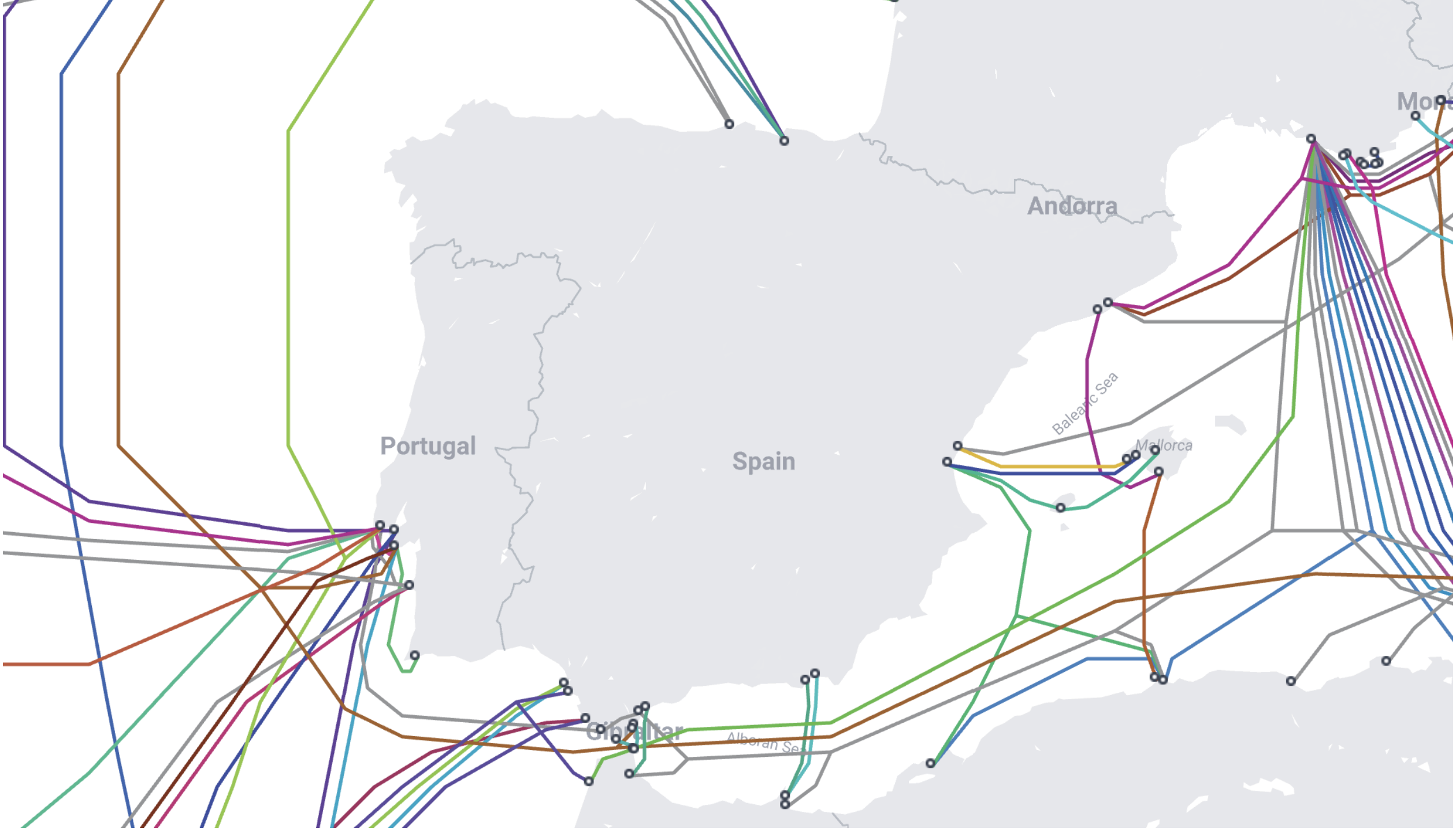
network-eacademy@lists.geant.org

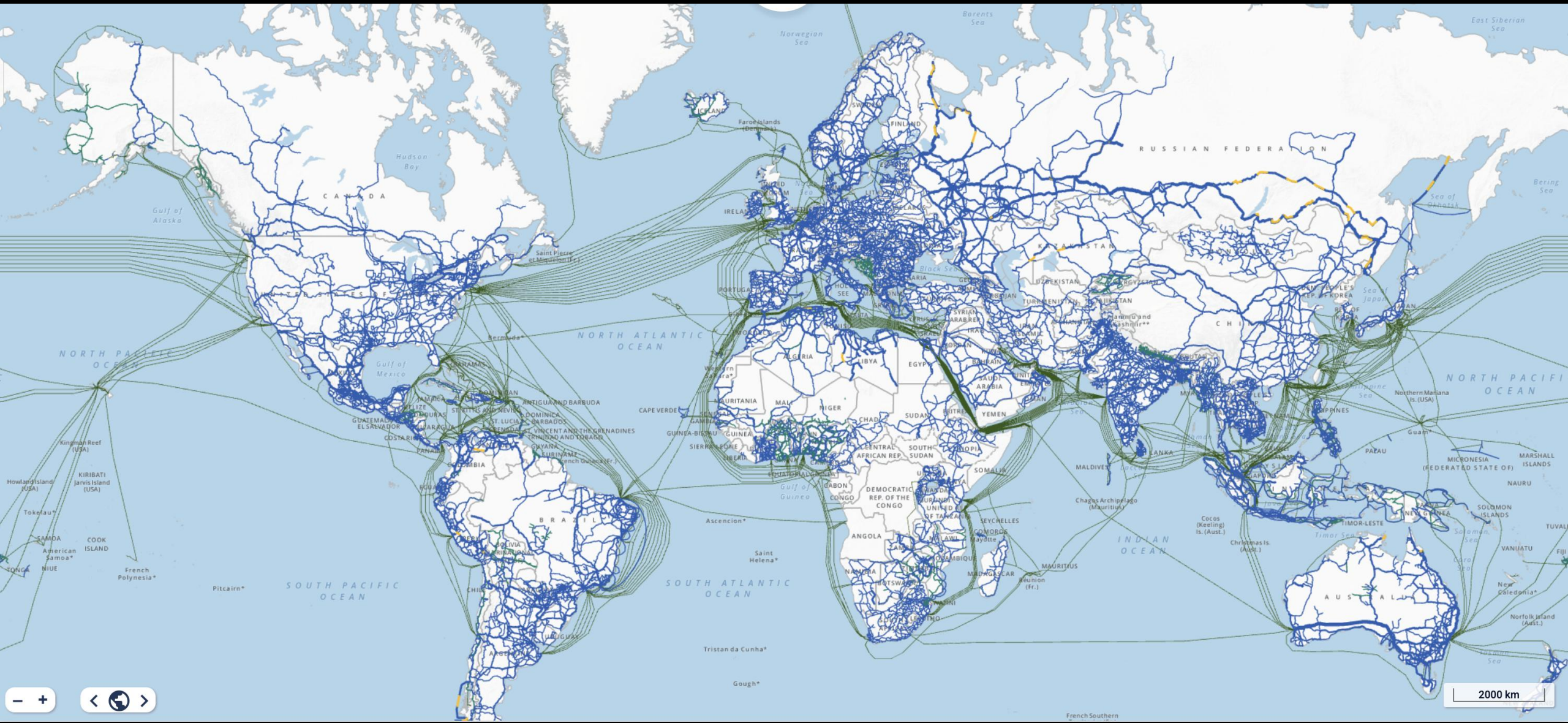
Agenda

- *What* fibres?
- What is Fibre Sensing?
- What we can detect
- How we detect it

What Fibres?


Greenland
Canada
United States
Mexico
Venezuela
Colombia
Brazil
Peru
Bolivia
Chile
Argentina
North Pacific Ocean
South Pacific Ocean
North Atlantic Ocean
South Atlantic Ocean
Indian Ocean
Iceland
Finland
Sweden
Norway
Russia
Poland
Germany
France
Spain
Ukraine
Türkiye
Kazakhstan
Mongolia
China
Afghanistan
Iraq
Iran
Pakistan
India
Thailand
Algeria
Libya
Egypt
Saudi Arabia
Mali
Niger
Chad
Sudan
Nigeria
Ethiopia
Kenya
DRC
Tanzania
Angola
Namibia
Botswana
Madagascar
Australia
New Zealand


Andorra
Portugal
Spain
Balearic Sea
Mallorca
Gibraltar
Alboran Sea


RUSSIAN FEDERATION
CANADA
BRAZIL
AUSTRALIA
NORTH ATLANTIC OCEAN
NORTH PACIFIC OCEAN
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
2000 km


PORTUGAL
SPAIN
ANDORRA
Andorra la Vella
MONACO
Monaco
San Marino
HOLY SEE
Vatican
Ligurian Sea
Balearic Islands
Tyrrhenian Sea
Gibraltar*
Alboran Sea
Rabat
Alger (Algiers)
Tunis
TUNISIA
200 km

What *is* Fibre Sensing – and what can we detect?

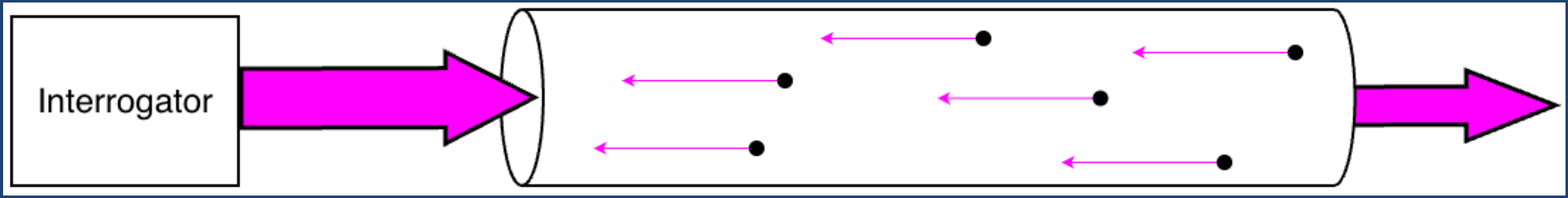
Ingredients for Fibre Sensing

- Fibres in the ground, the sea or the air
- Light injected into the fibre
- External forces affecting the fibre
- Device(s) to detect changes

Detectable Changes

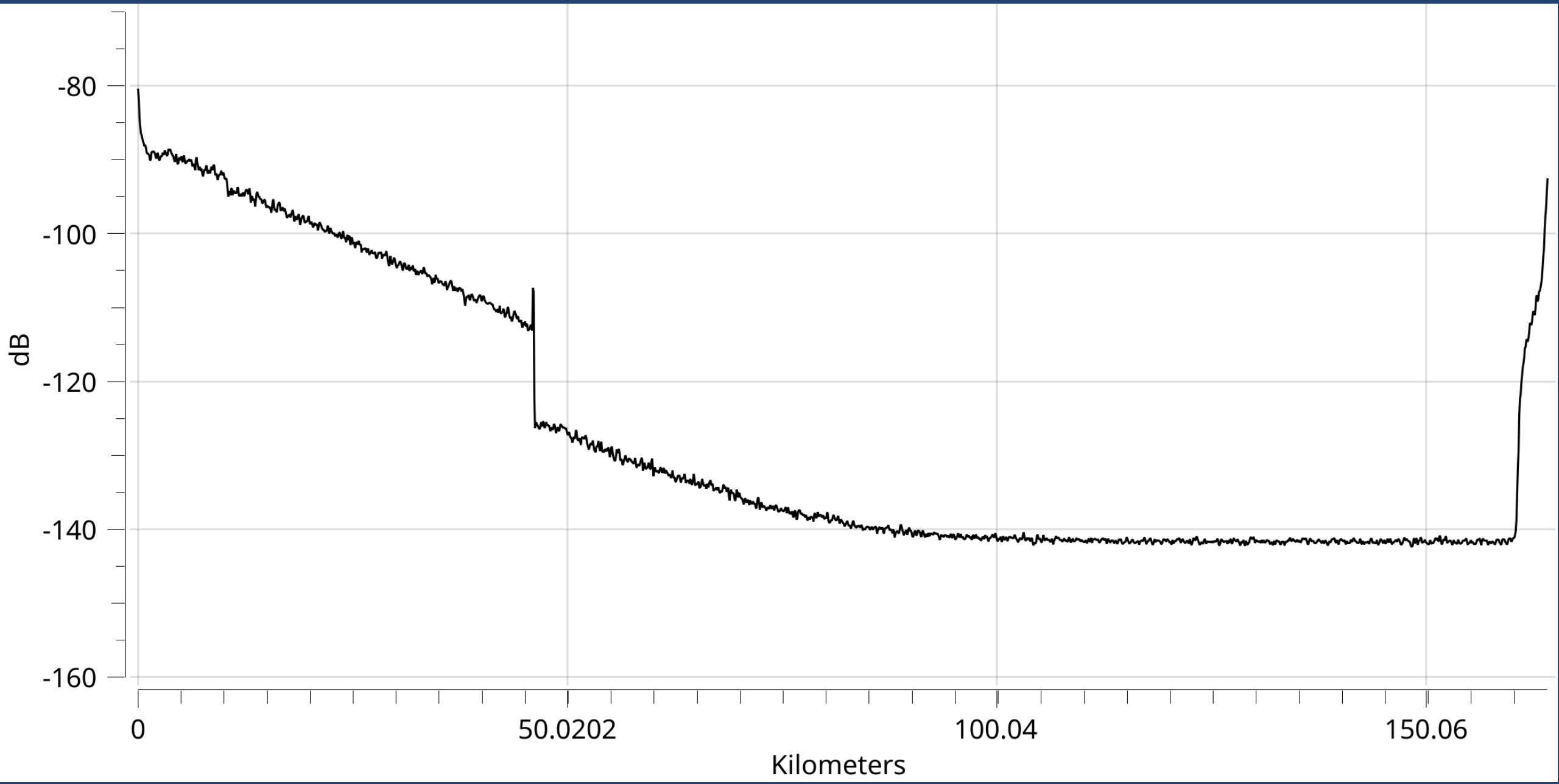
- Strain
- Vibrations
- Pressure
- Temperature

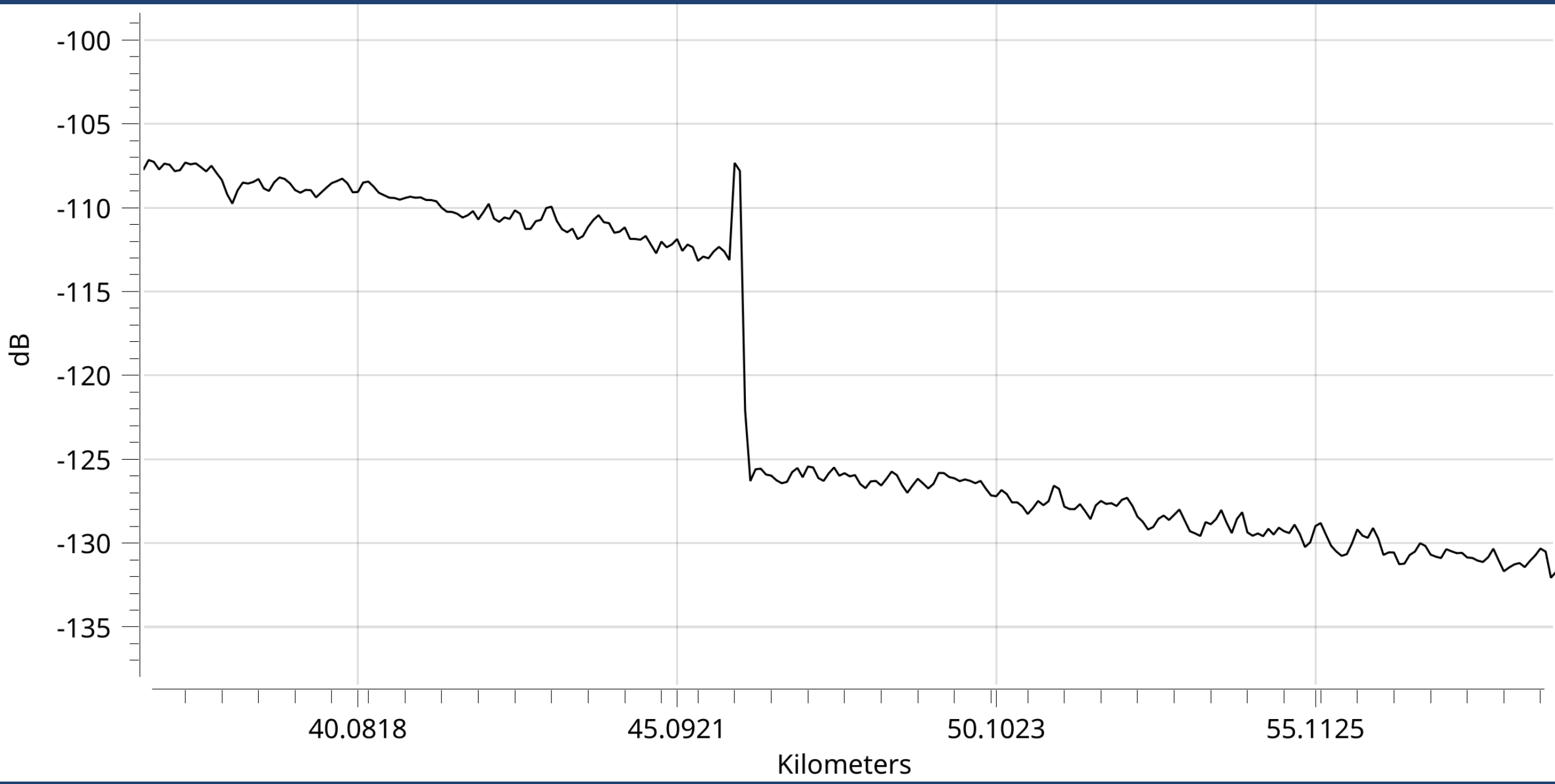
Rayleigh Backscattering

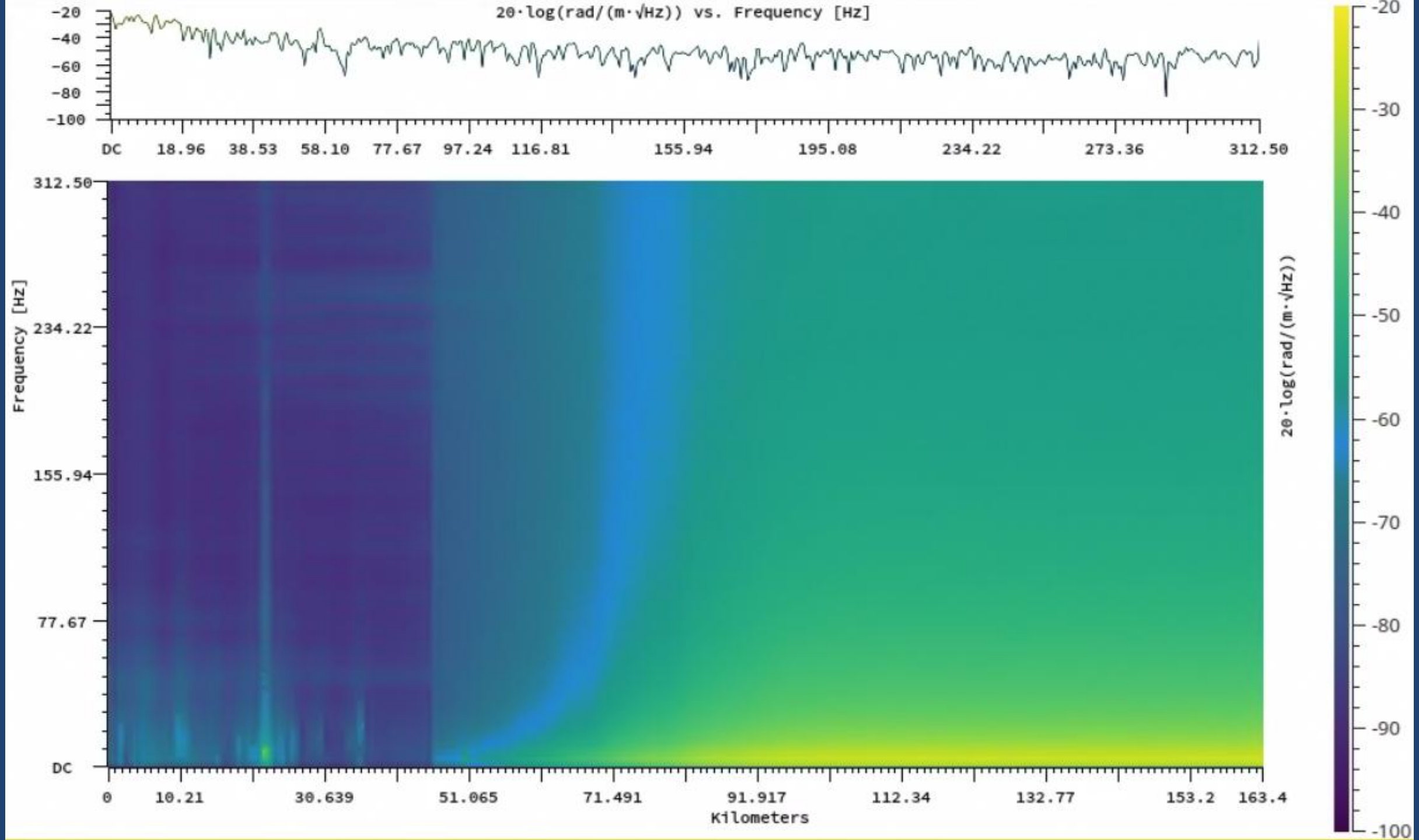


Distributed Acoustic Sensing (DAS)

NSF USGS GAGE SAGE EarthScope Consortium

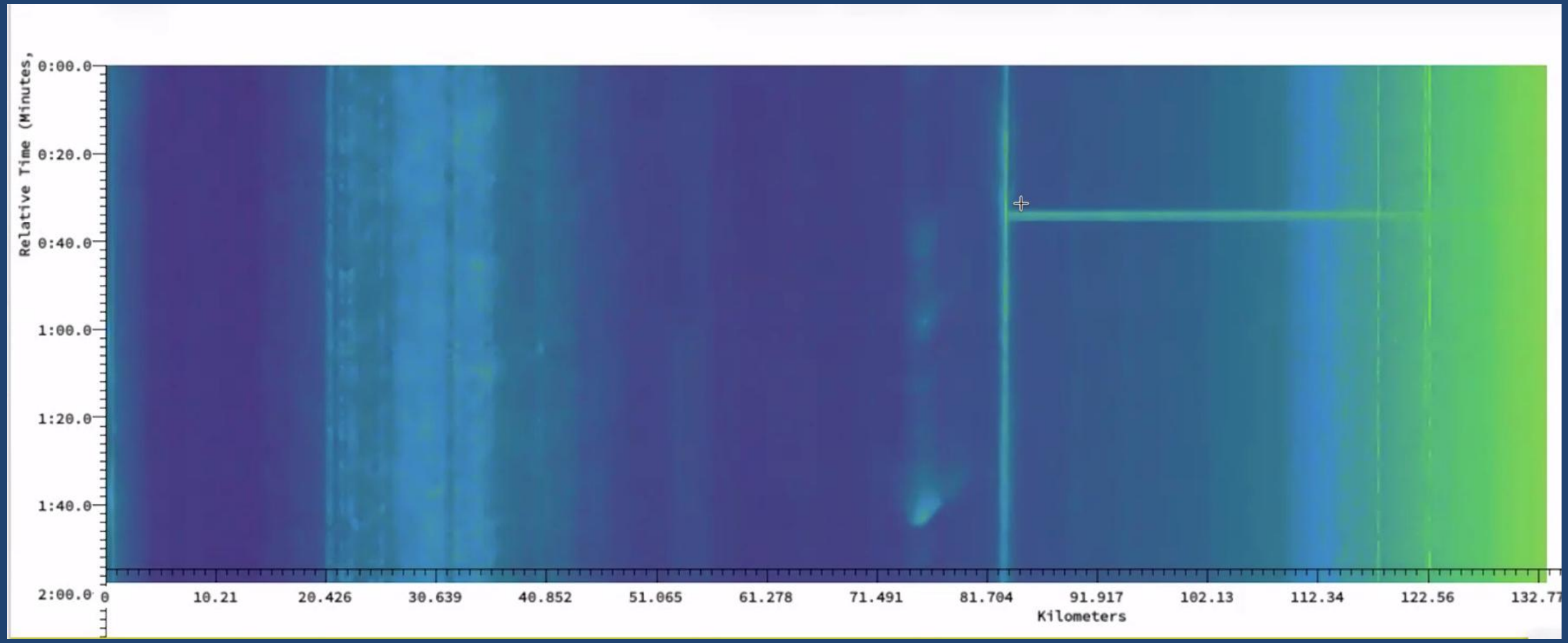

-80
-100
-120
-140
-160
dB
0
50.0202
100.04
150.06
Kilometers


-100
-105
-110
-115
-120
-125
-130
-135
dB
40.0818
45.0921
50.1023
55.1125
Kilometers


20·log(rad/(m·√Hz)) vs. Frequency [Hz]
-20
-40
-60
-80
-100
DC
18.96
38.53
58.10
77.67
97.24
116.81
155.94
195.08
234.22
273.36
312.50
Frequency [Hz]
312.50
234.22
155.94
77.67
DC
0
10.21
30.639
51.065
71.491
91.917
112.34
132.77
153.2
163.4
Kilometers
20·log(rad/(m·√Hz))
-20
-30
-40
-50
-60
-70
-80
-90
-100

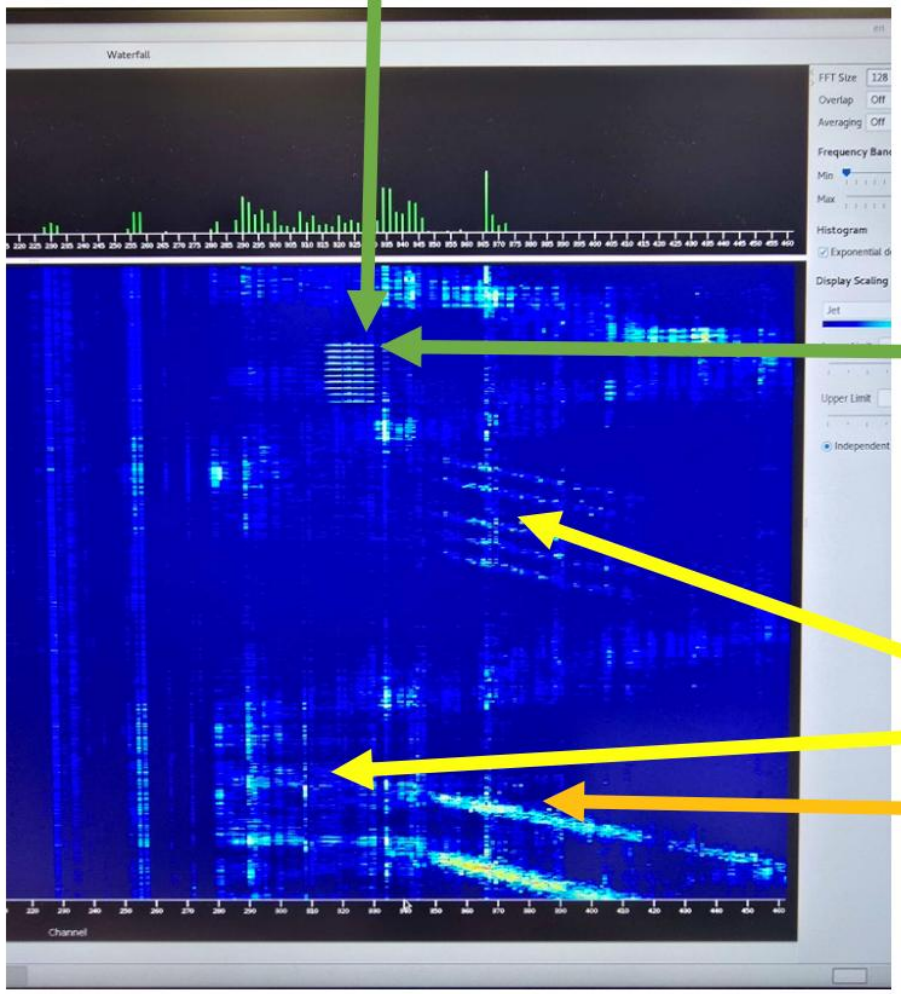
Break detection – Fishing Vessel

Src : Chris Atherton@GÉANT



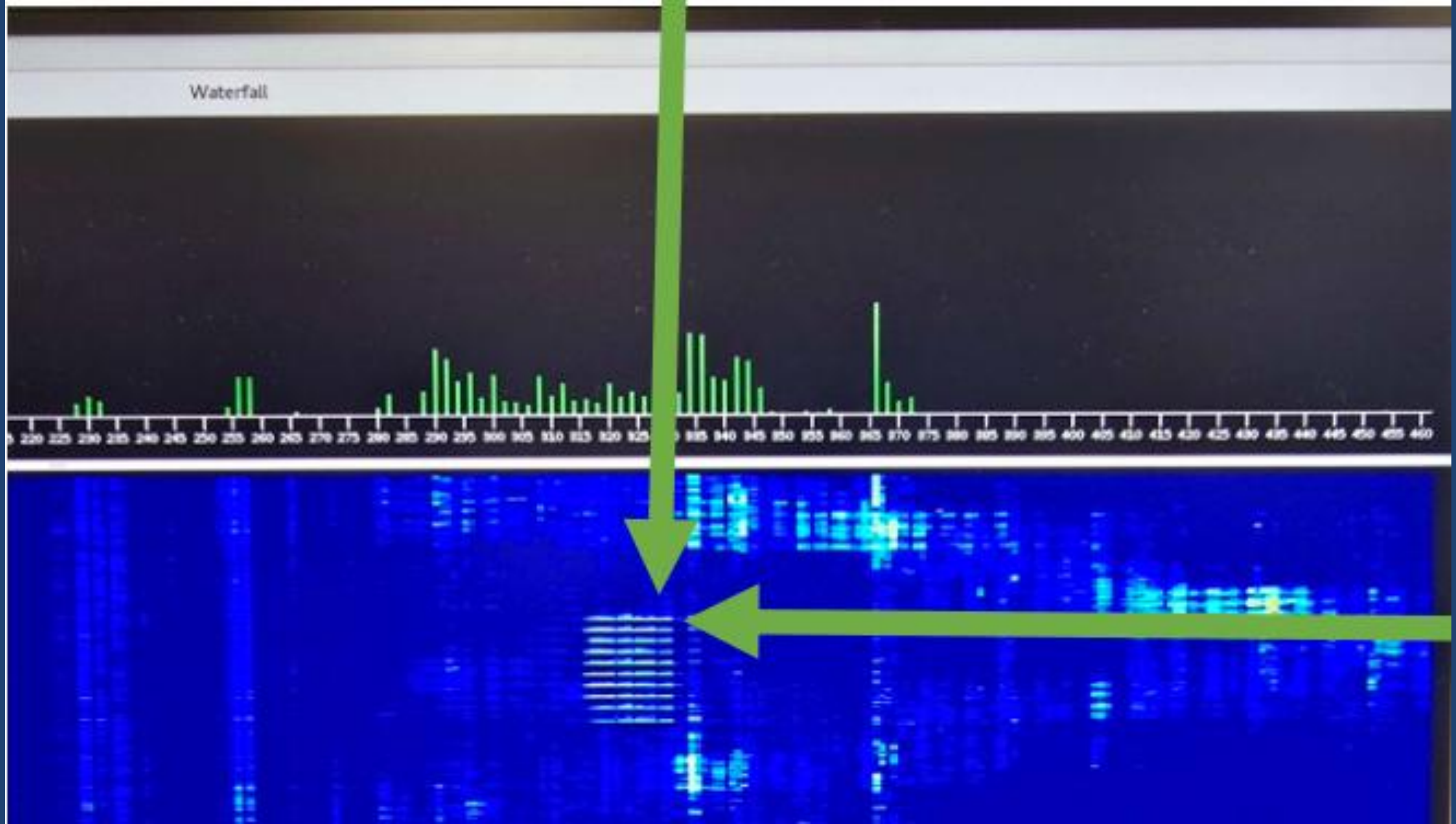
Src : Piotr Turowicz@PCSS

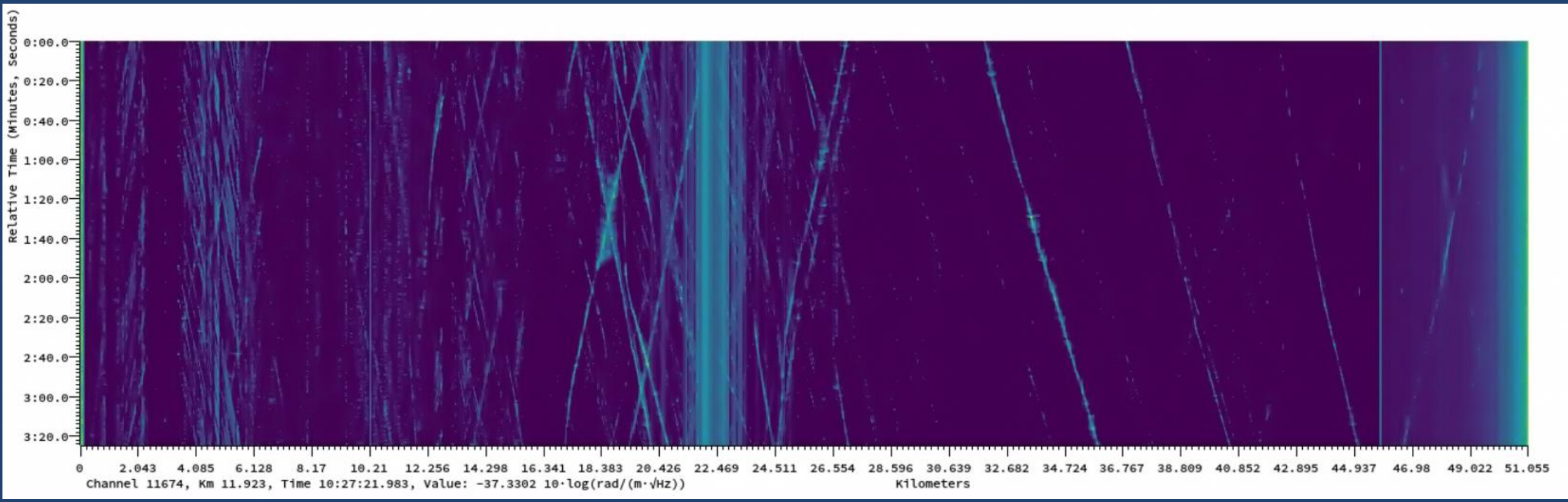
Poznan street with manhole and jumping (10x)

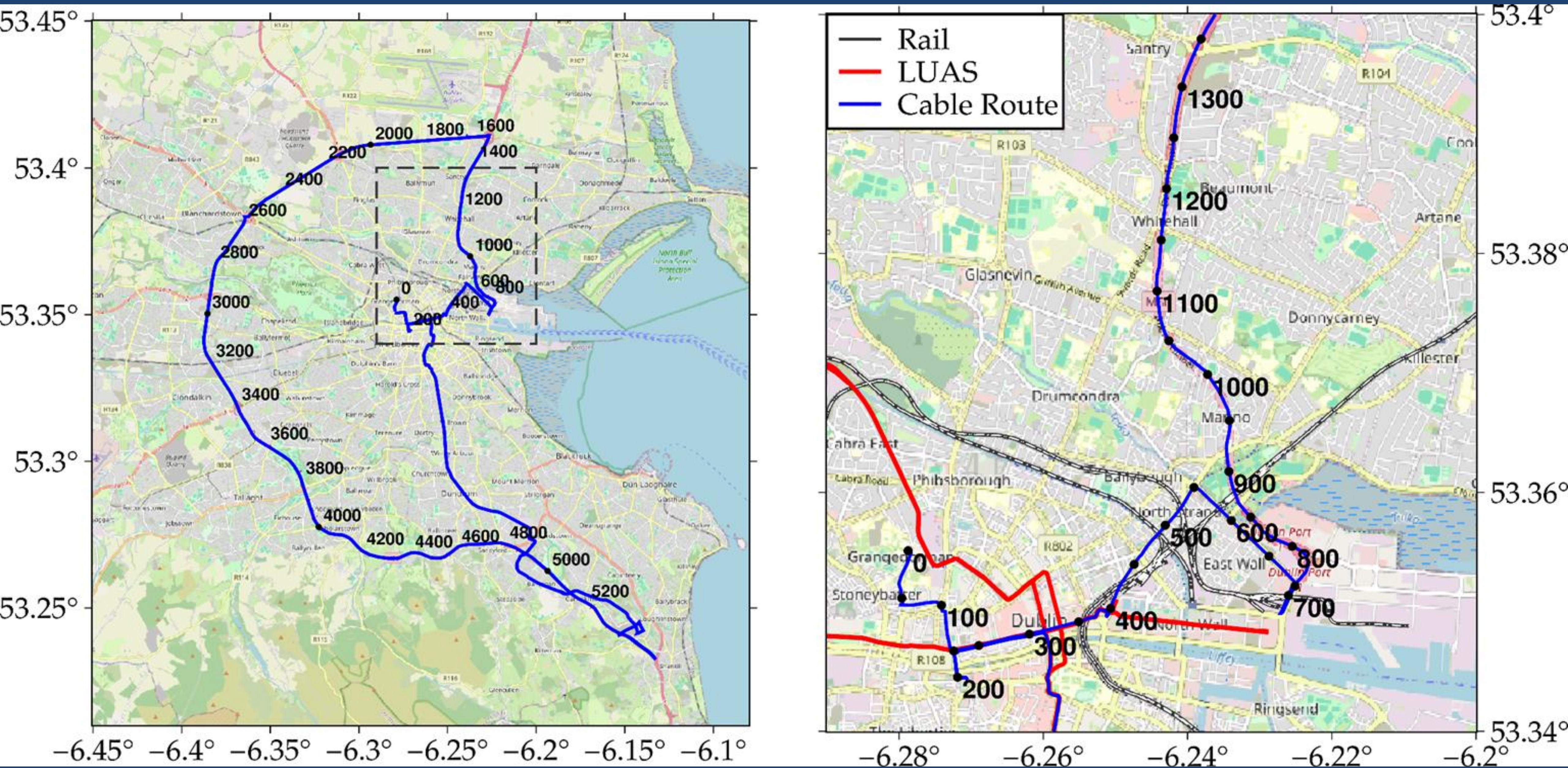


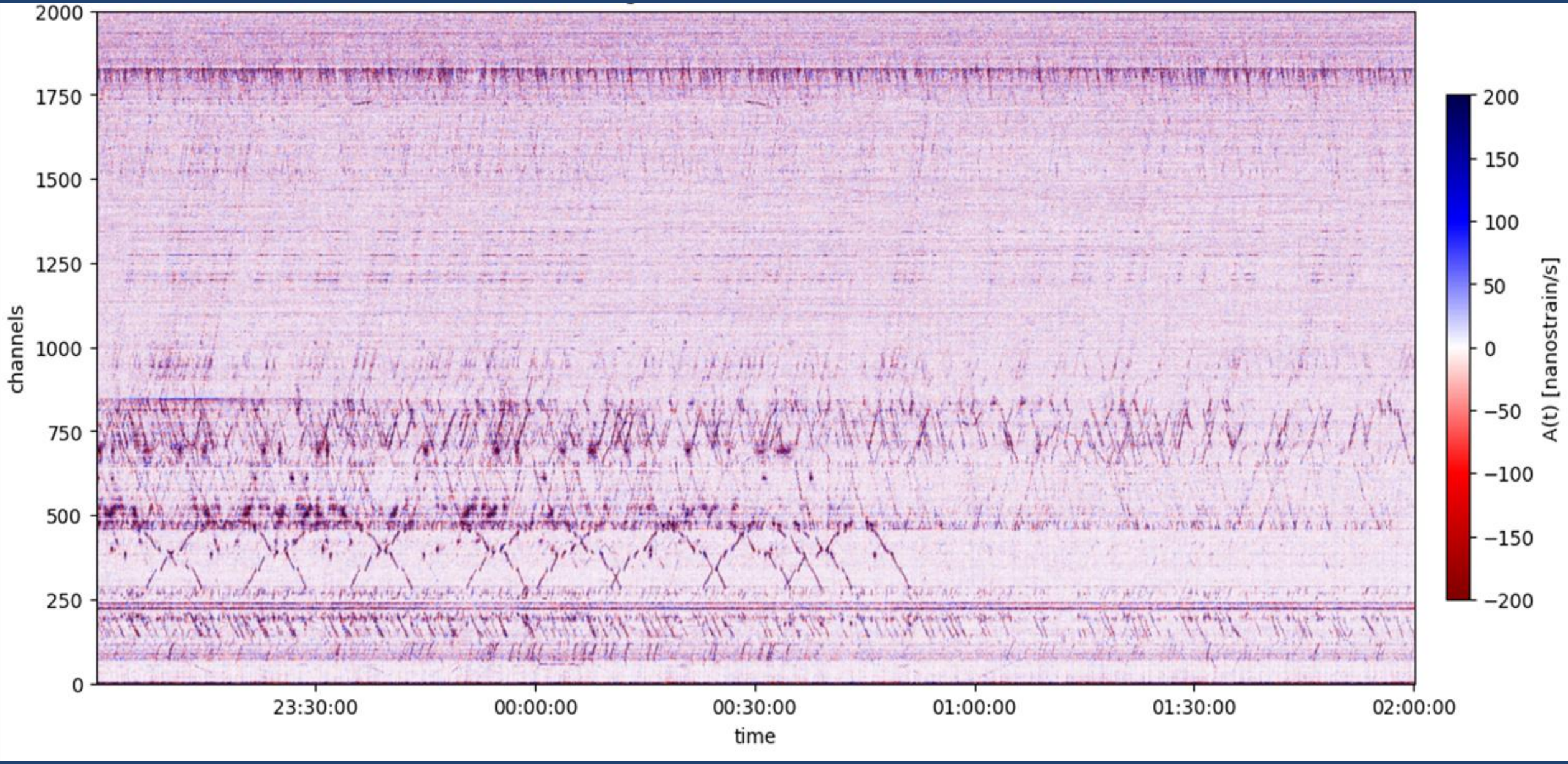
Poznan street – car traffic (both direction)

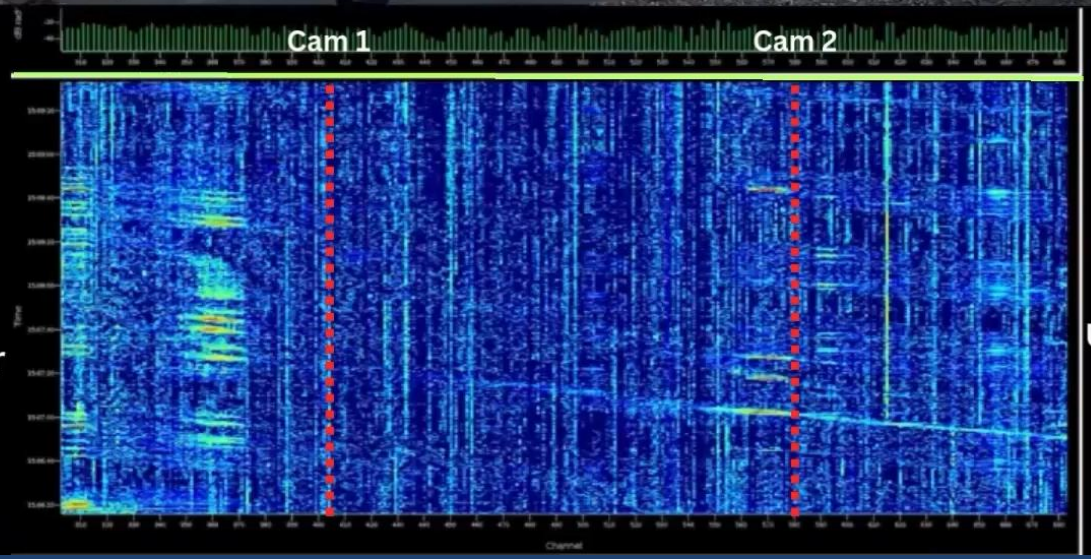
Poznan street – trams


Waterfall


Relative Time (Minutes, Seconds)
0:00.0
0:20.0
0:40.0
1:00.0
1:20.0
1:40.0
2:00.0
2:20.0
2:40.0
3:00.0
3:20.0
0
2.043
4.085
6.128
8.17
10.21
12.256
14.298
16.341
18.383
20.426
22.469
24.511
26.554
28.596
30.639
32.682
34.724
36.767
38.809
40.852
42.895
44.937
46.98
49.022
51.055
Channel 11674, Km 11.923, Time 10:27:21.983, Value: −37.3302 10·log(rad/(m·√Hz))
Kilometers


53.45°
53.4°
53.35°
53.3°
53.25°
−6.45°
−6.4°
−6.35°
−6.3°
−6.25°
−6.2°
−6.15°
−6.1°
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
4800
5000
5200
Rail
LUAS
Cable Route
53.4°
53.38°
53.36°
53.34°
−6.28°
−6.26°
−6.24°
−6.22°
−6.2°
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
Santry
Beaumont
Whitehall
Artane
Glasnevin
Donnycarney
Killester
Drumcondra
Marino
Cabra East
Phibsborough
Ballybough
North Strand
East Wall
Grangegorman
Stoneybatter
Dublin
North Wall
Ringsend
R103
R104
R802
R108


2000
1750
1500
1250
1000
750
500
250
0
channels
23:30:00
00:00:00
00:30:00
01:00:00
01:30:00
02:00:00
time
200
150
100
50
0
−50
−100
−150
−200
A(t) [nanostrain/s]



Tyndall,
DAS Interrogator

Tyndall
National Institute
Institiúid Náisiúnta

UCC

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BRINGING PHOTONICS TO LIFE

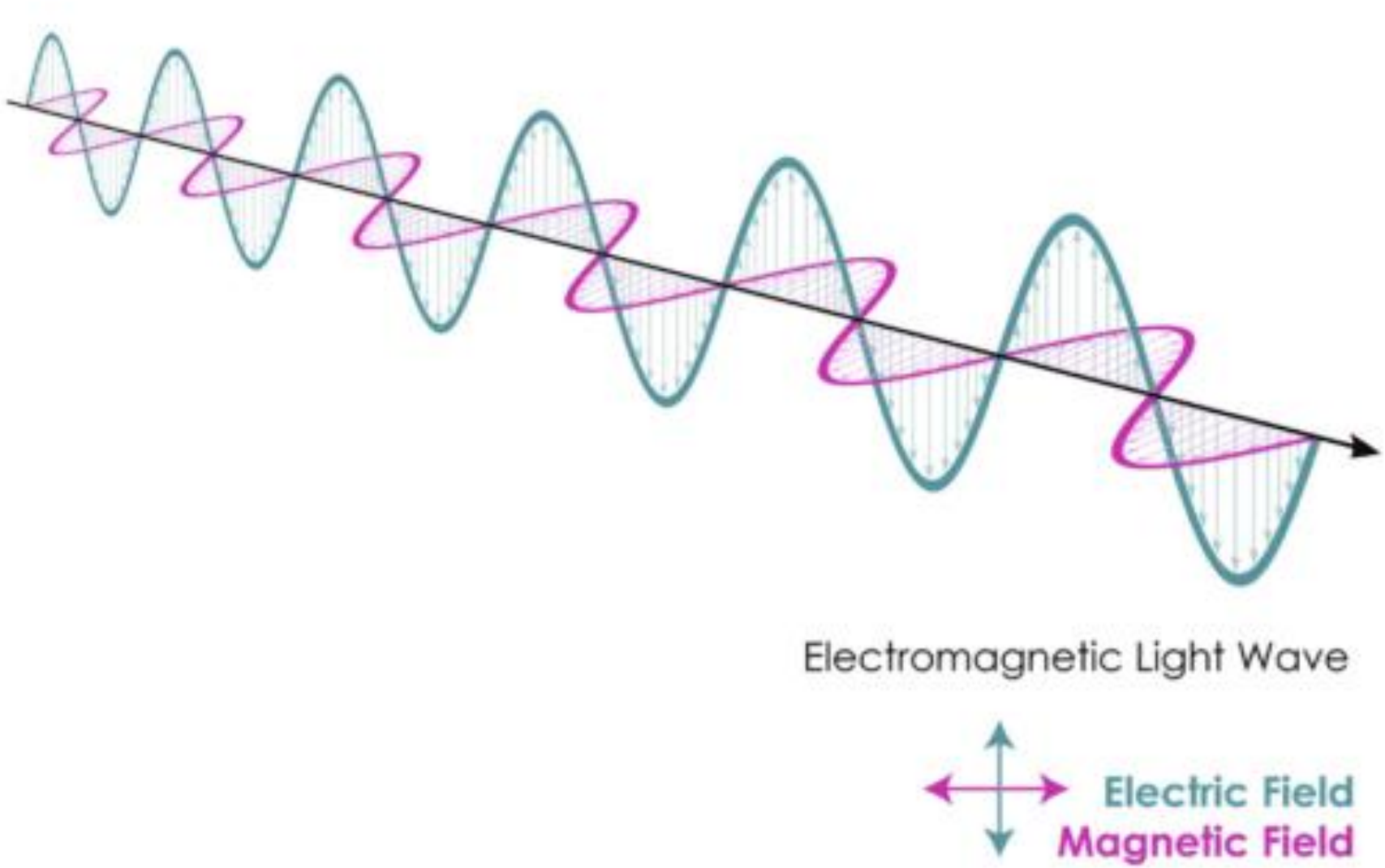
Backscattering limitations

- Distance (70-100km)

- Will **not** pass through amplifiers/repeaters!

Forward-based sending – State of Polarisation (SoP

- Devices at both ends of the fibre
- Devices should be tightly time-synchronised
- Signals can pass through amplifiers/repeaters!



Src : April Petrusma @ Insight News.au

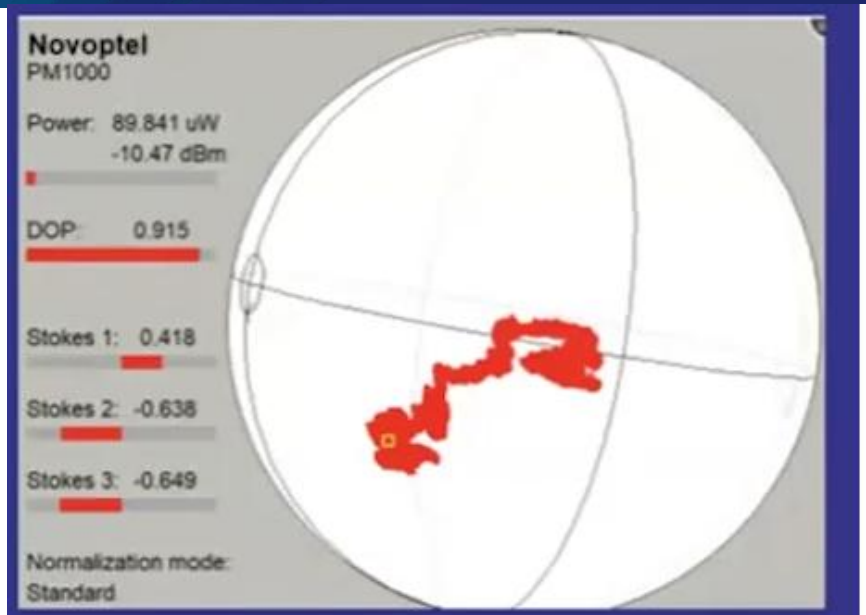
Jules Henri Poincaré

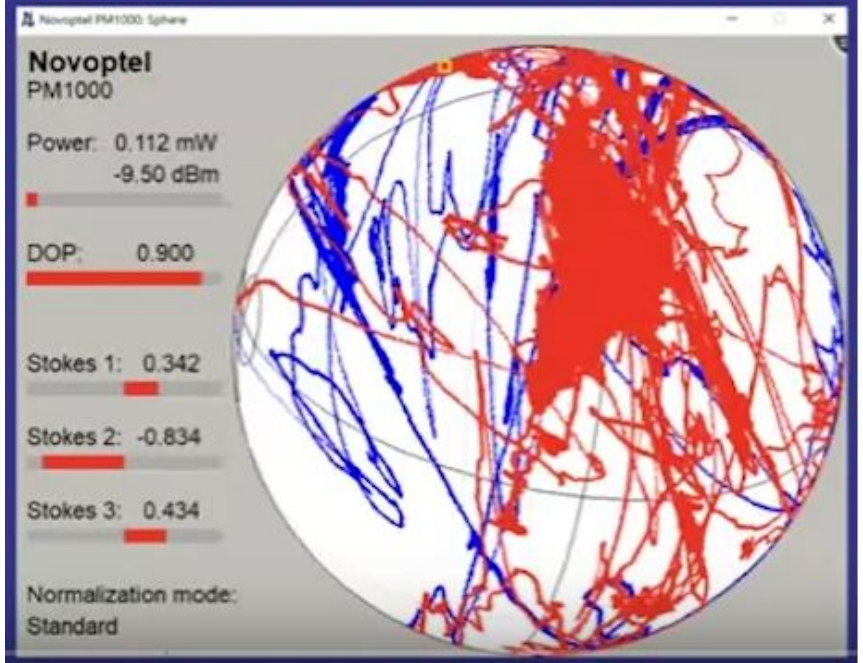
- French mathematician
- 1854 – 1912

Src : Dibner Library of the History of Science & Technology

Poincaré Sphere

- Plots “Stoke Vectors”
- Tracks SoP changes
- Red in the front; blue in the back





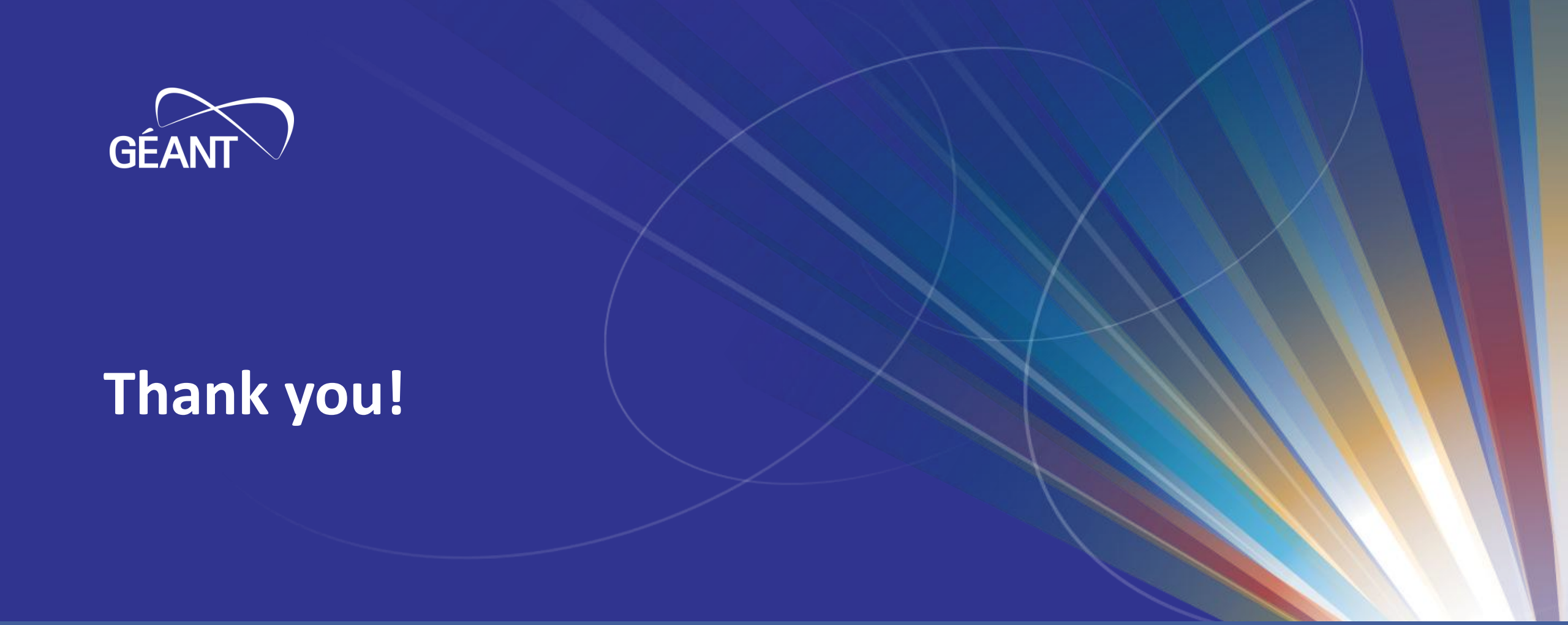
Src : Jan Radil, eAcademy Fibre Sensing Group

GÉANT eAcademy https://eacademy.geant.org

- Network Orchestration, Automation and Virtualisation (OAV)
- Artificial Intelligence
- Quantum Communications
- Optical Time & Frequency Networks (OTFN)
- New : Fibre Sensing!

Fibre Sensing Learning Units

- Introduction to Fibre Sensing
- Data Acquisition in the Fibre Sensing Ecosystem
- Distributed Temperature & Strain Sensing (DTSS)
- NREN Use Cases



Thank you!

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