Radar Environment RF Generation

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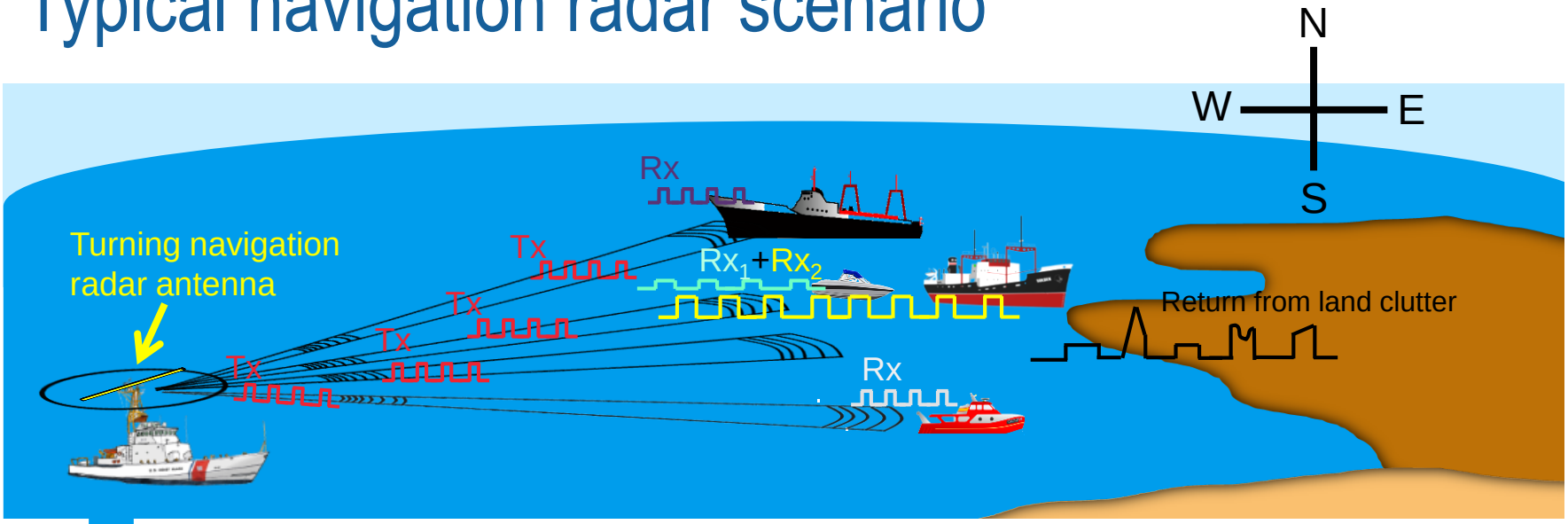
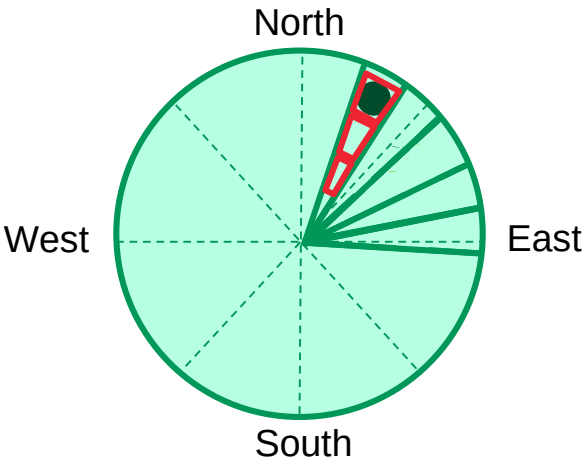
Typical navigation radar scenario

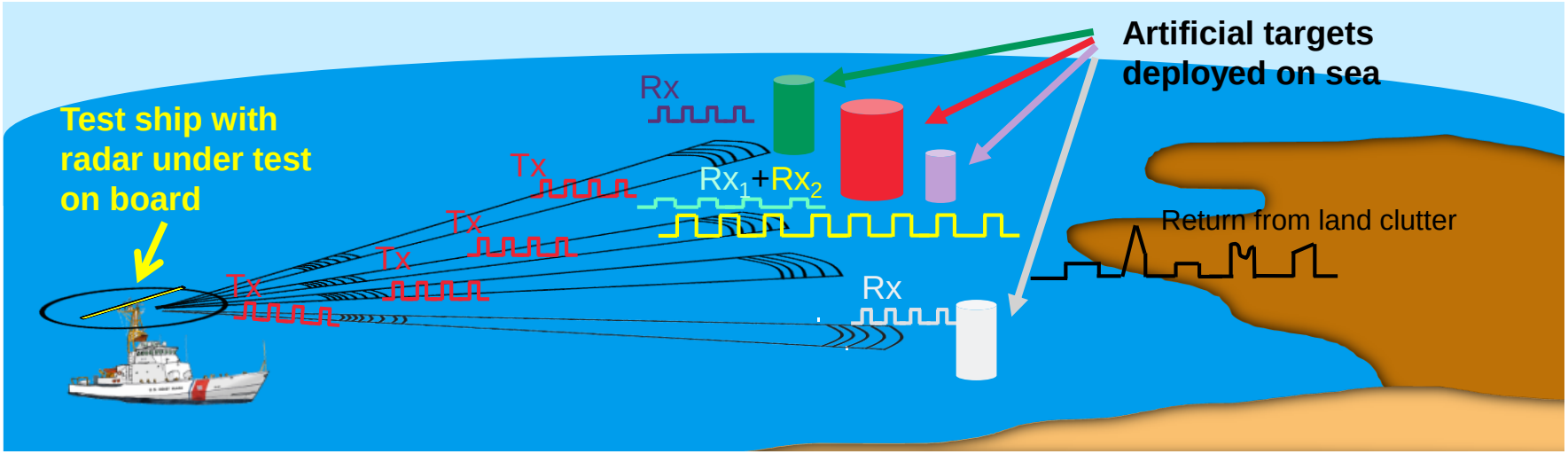




Visualization on a radar screen

- Echoes are displayed in so called “range cells“
- Coherent radars can also measure speed and can therefore also display an echo in a “Doppler cell“
- The larger the radar return signal, the larger the radar cross section i.e. the object, the larger the dot on the screen

Conventional Test set-up for navigation radar testing

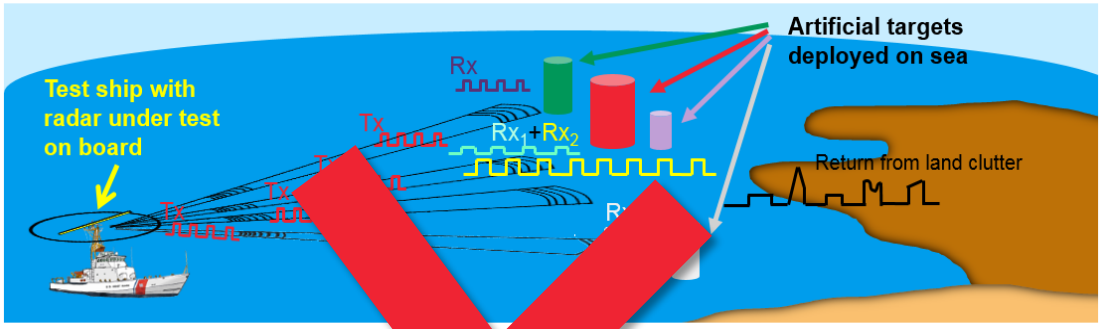


- Test Concept for Navigation Radars
  - Mount a real radar under test on a boat
  - Deploy artificial targets at the sea
- Test Concept for airborne radars
  - Set up a flight campaign with artificial targets or use civil aircrafts
- Test concept for ground radars
  - Set-up field-test in large area to test performance

Motivation and Approach

Sea Clutter Simulation

Target Simulation



Field-to-lab

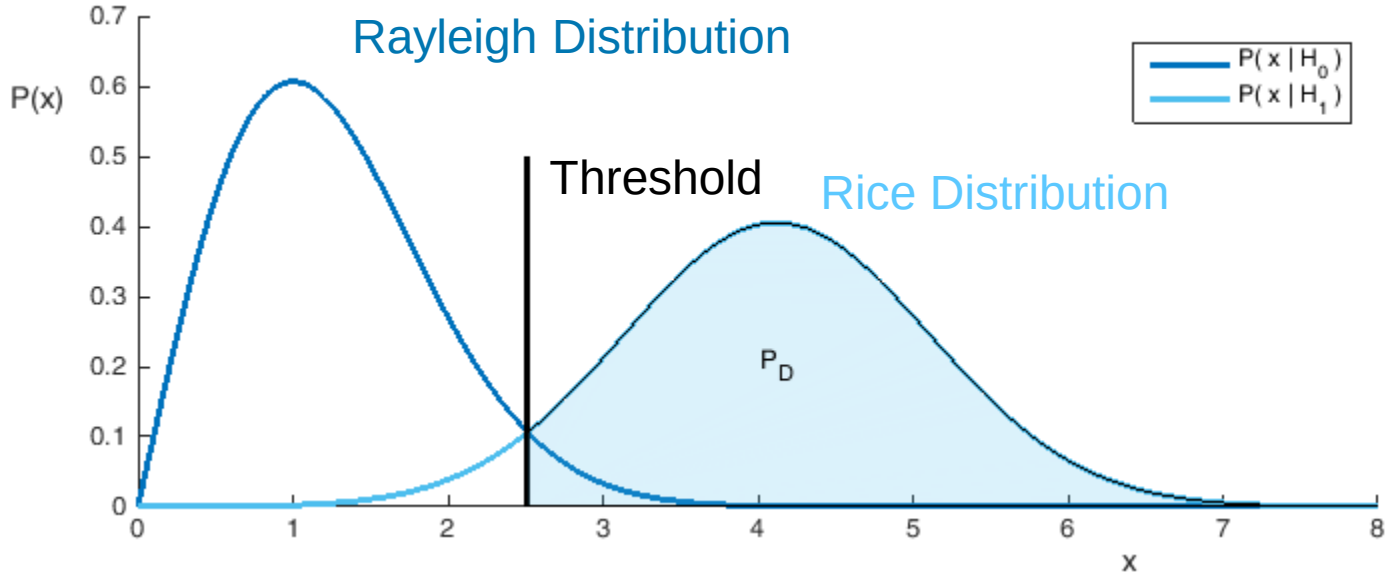
Reduce
Cost, complexity & test time

Improve
Accuracy, reliability & repeatability

Sea clutter generation

Radar Detection

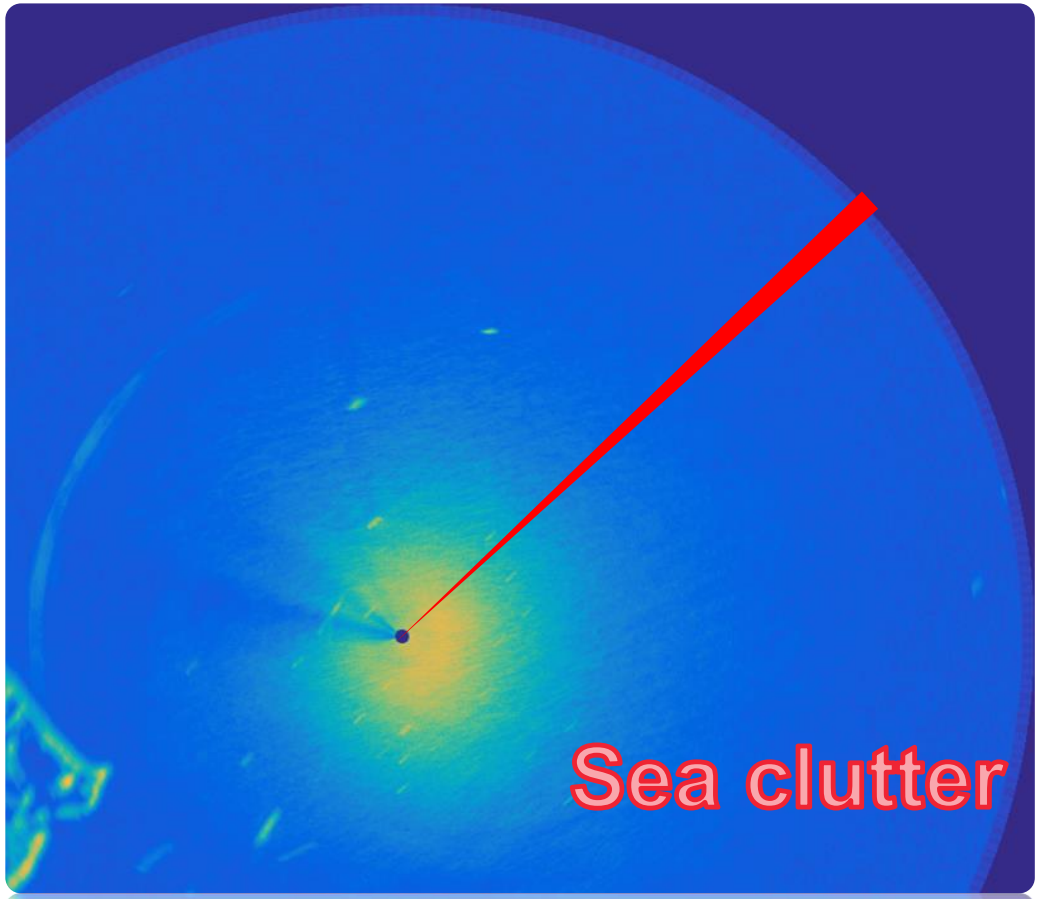
Probability Density Function

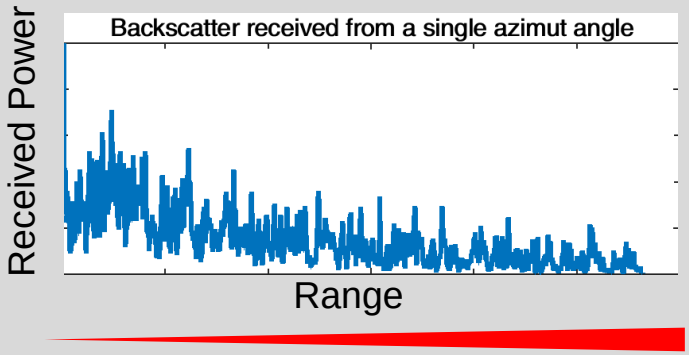


P_{FA}	False Alarm Probability
P_M	Probability of Missing a Target
P_D	Probability of Missing Detection

Typical Sea Clutter

PPI view





How to simulate time and spatial correlated sea clutter?

Two scale model of the sea surface

- Capillary waves
  - Wavelength of centimeters or less
  - Driven by local wind gusts

  → **Stochastic model**

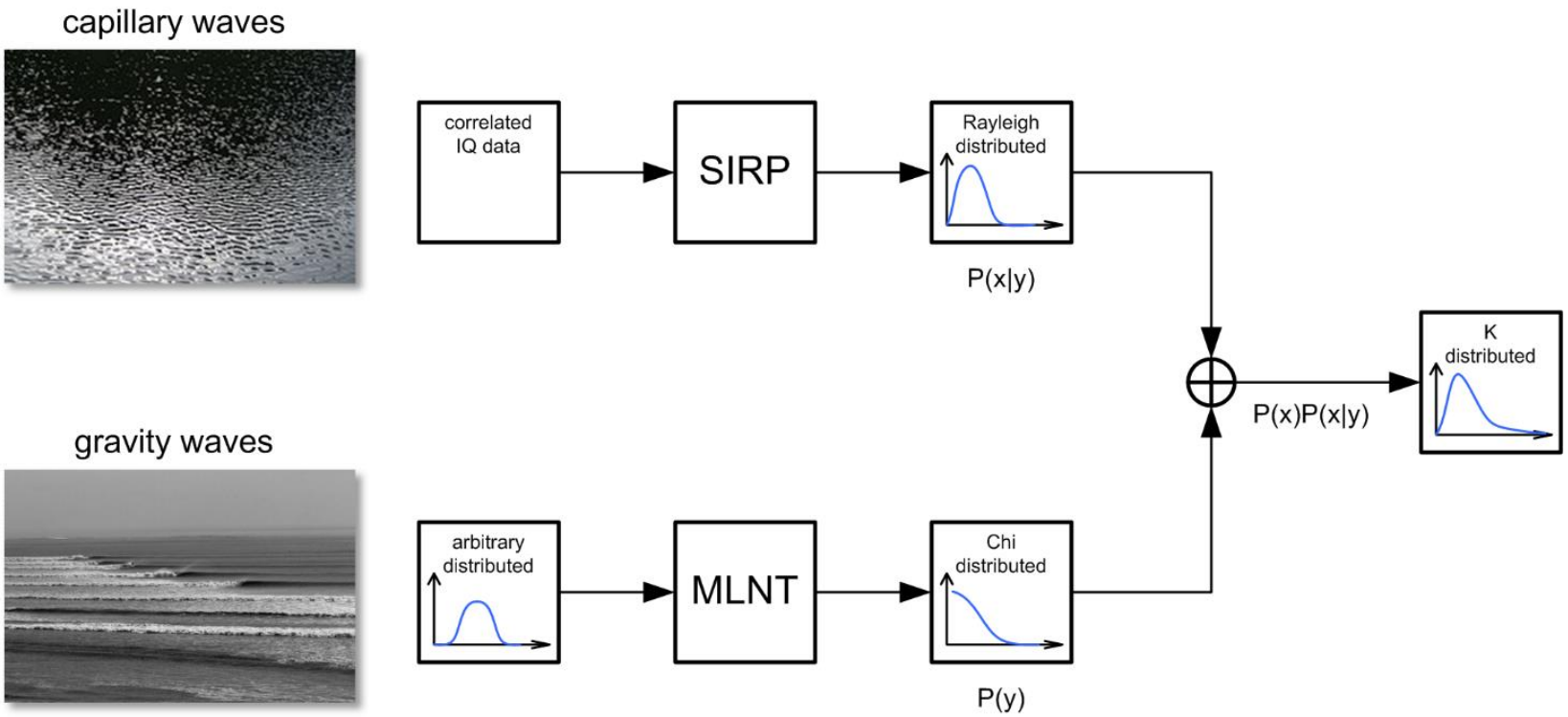
- Gravity waves
  - Wavelength of a few hundred meters down to a meter
  - Created by stable winds over a large area

  → **Physical model**

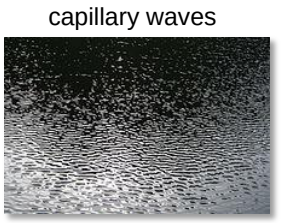
Courtesy of wikipedia.org

Courtesy of waterswaytravel.com

Two scale model of the sea surface

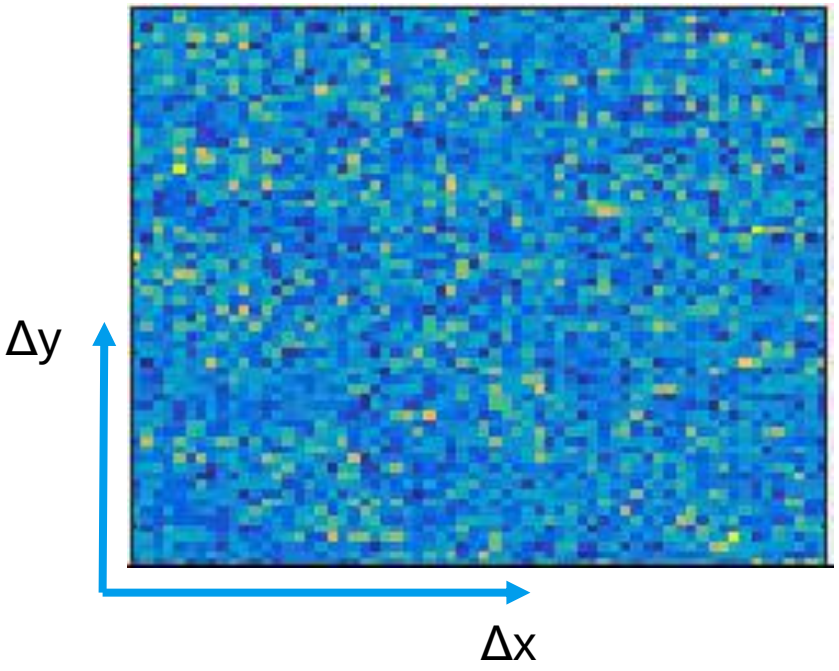


Capillary waves
Stochastic model



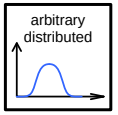
- Following Rayleigh distribution
- **SIRP procedure** can be used for generation if IQ data is available
- Otherwise **uncorrelated Rayleigh distributed noise** with mean level according to physical model

Rayleigh distributed noise:



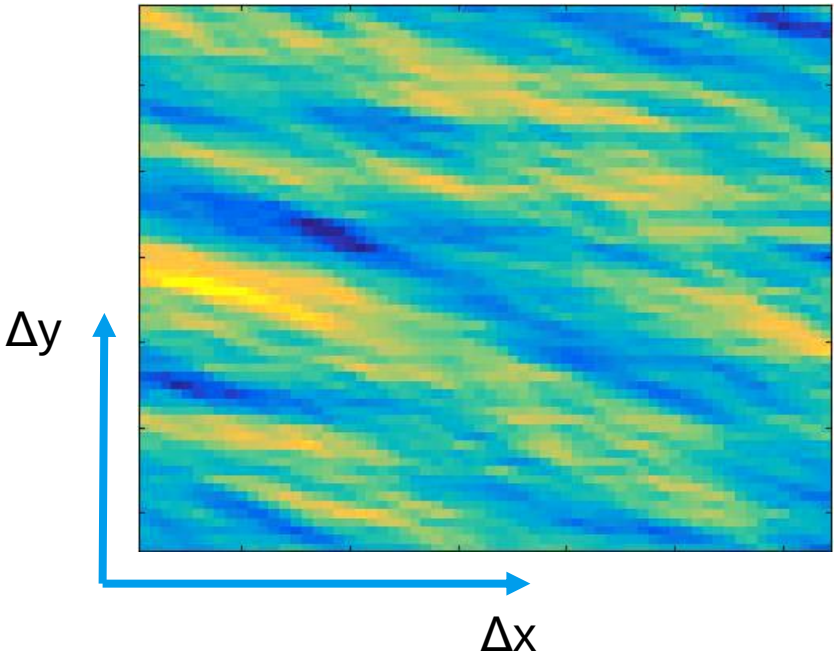
Gravity Waves
Physical Model

gravity waves



- Use established model to simulate sea surface
  - Parameters: average wave height and period, spreading factor, sampling frequency
- Transform height of sea surface to have a Chi-distribution
  - Transformation is performed with the help of memoryless nonlinear transformation (**MLNT**)
  - Shape parameter can be estimated using available formulas

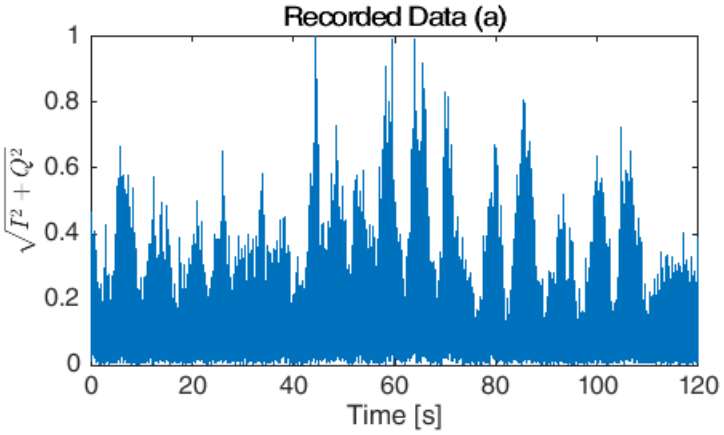
Simulation of sea surface heights

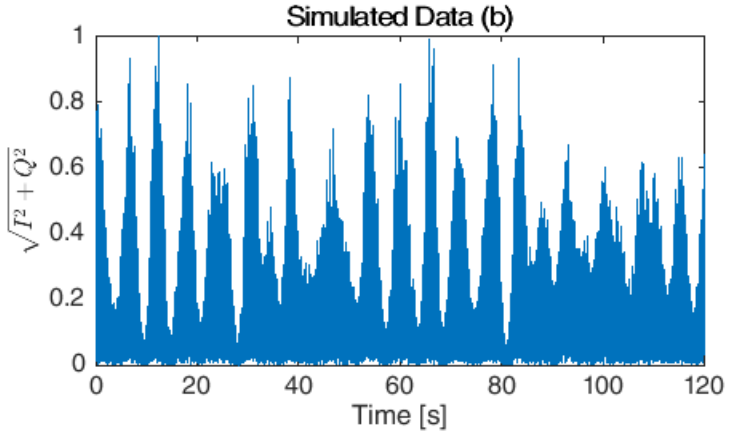


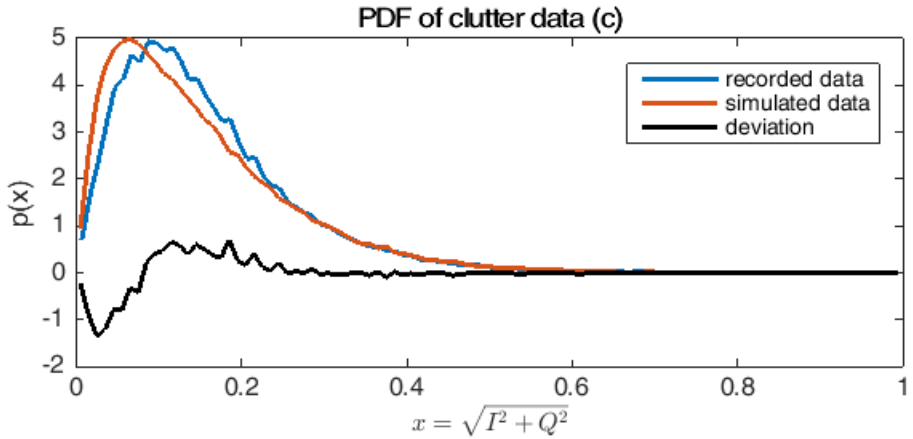
Data verification and signal generation

IPIX data

recorded on Canadian East Coast in 1993







Deviation of moments [%]

1st order: -4.7%

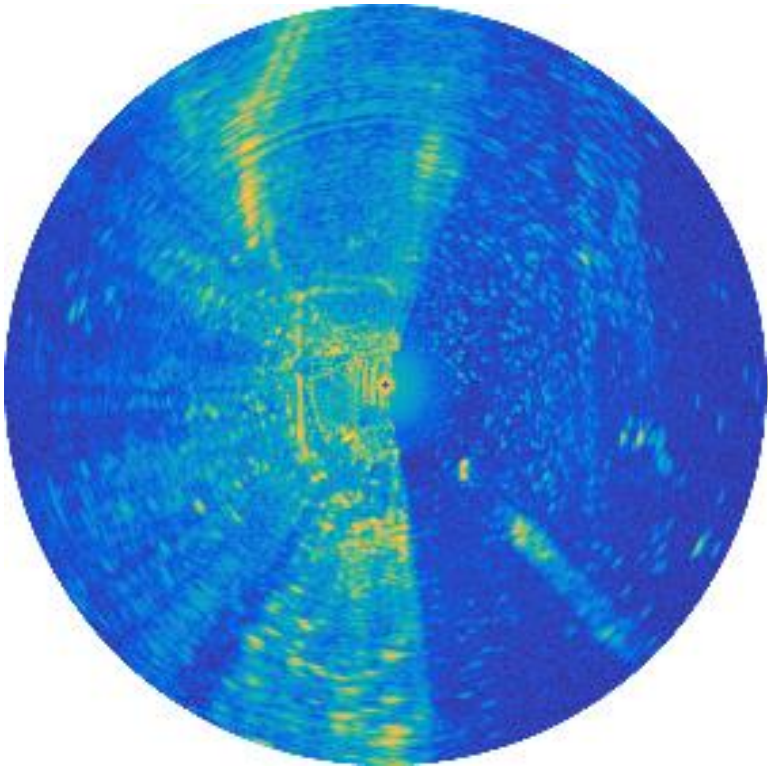
2nd order: -2.9%

3rd order: 0.31%

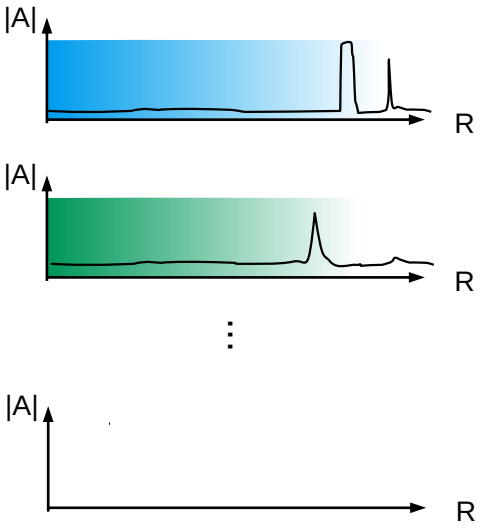
4th order: 2.9%

KS-Test passed in 83% using significance level α=0.05

Environment to multisegment waveform

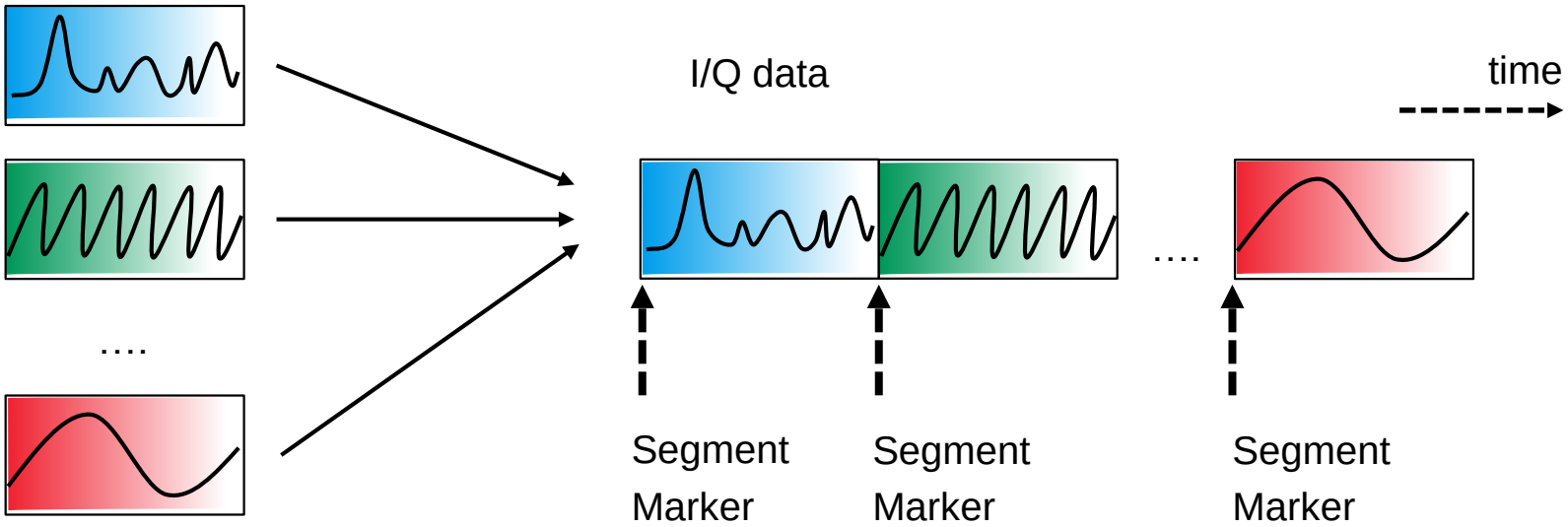


Map environment
to waveforms

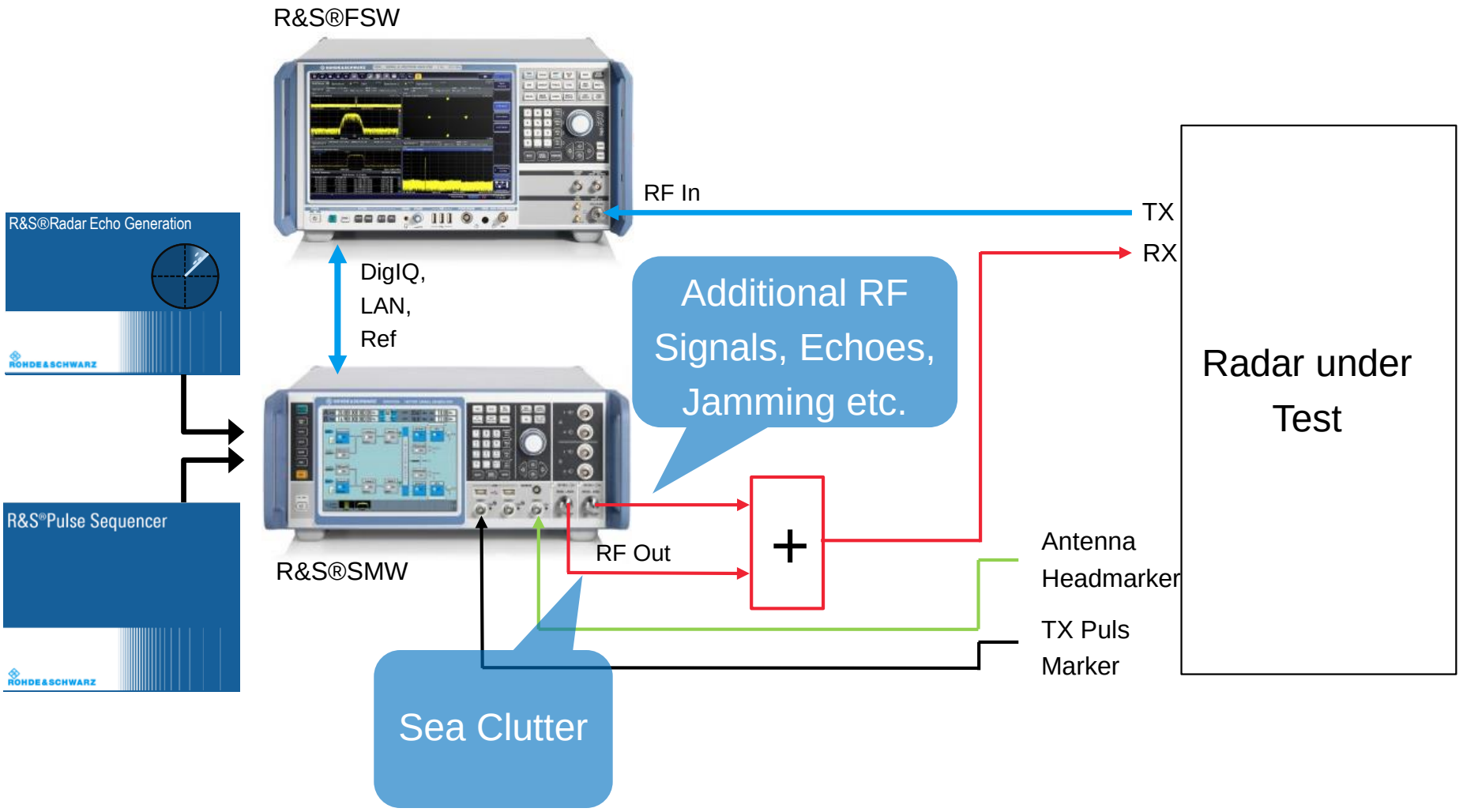


Environment simulation using multisegment waveform (MSW)

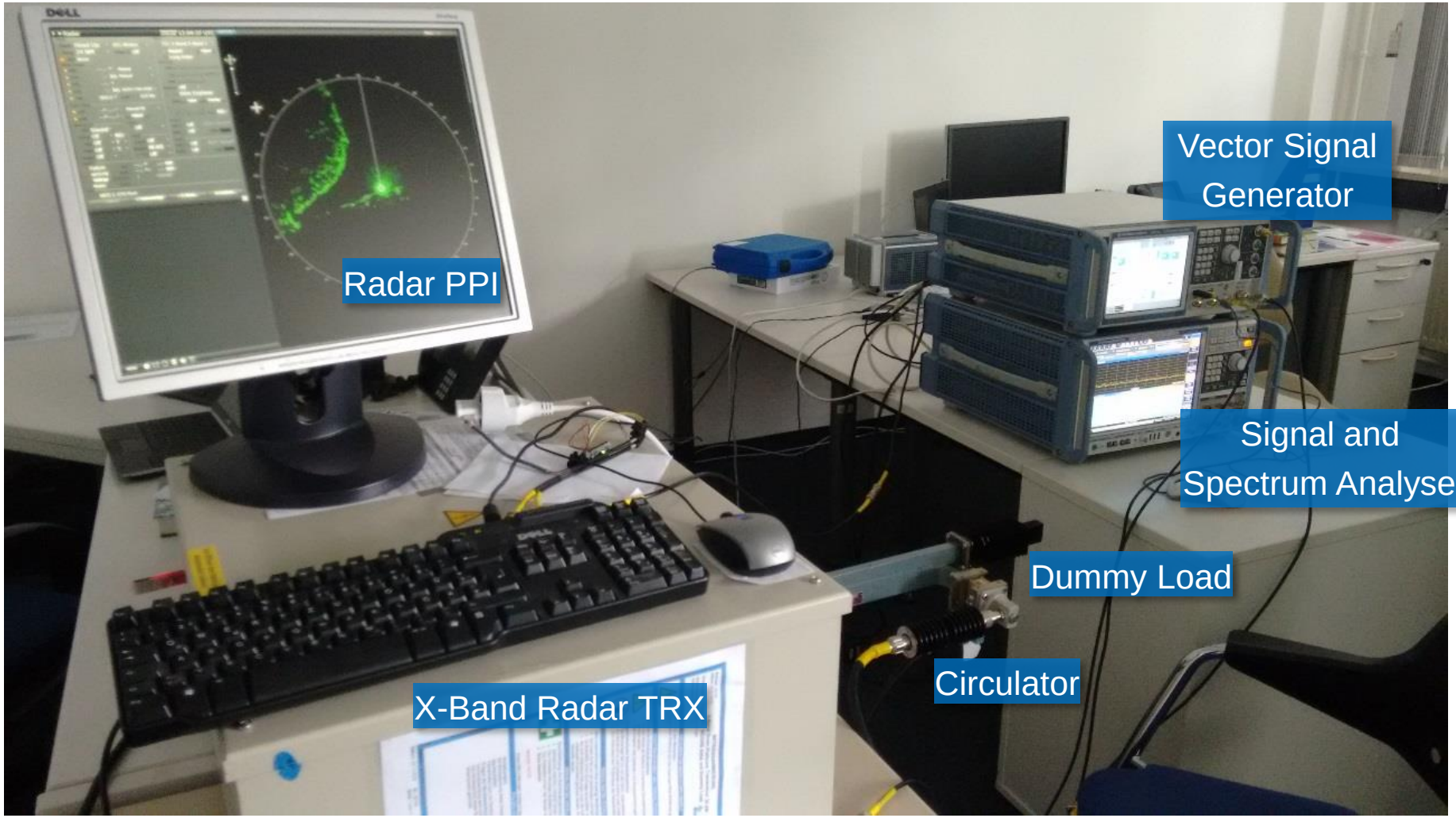
- Multisegment waveform (MSW) consists of multiple independent waveforms
- Each radar “TX Pulse” triggers a segment (and the next segment…)



Radar echo generation and environment simulation



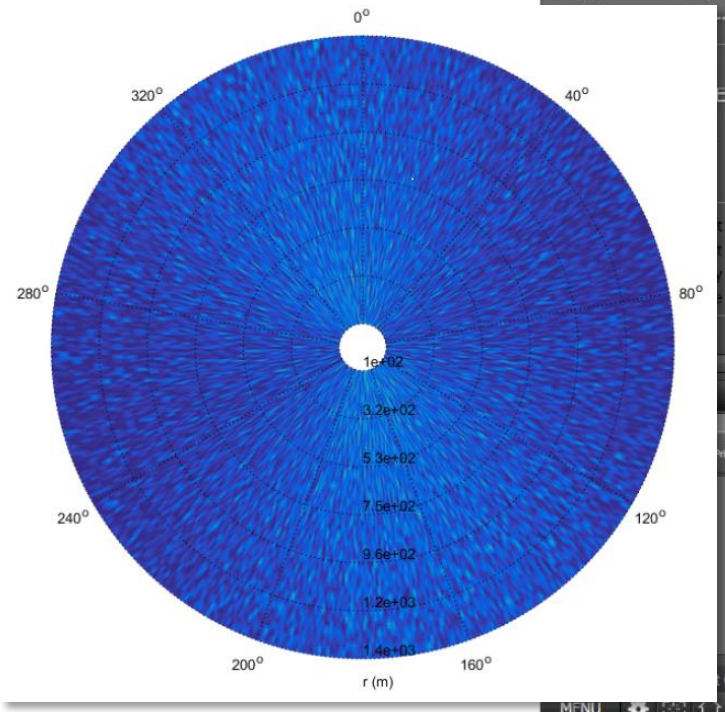
Measurement setup in the laboratory

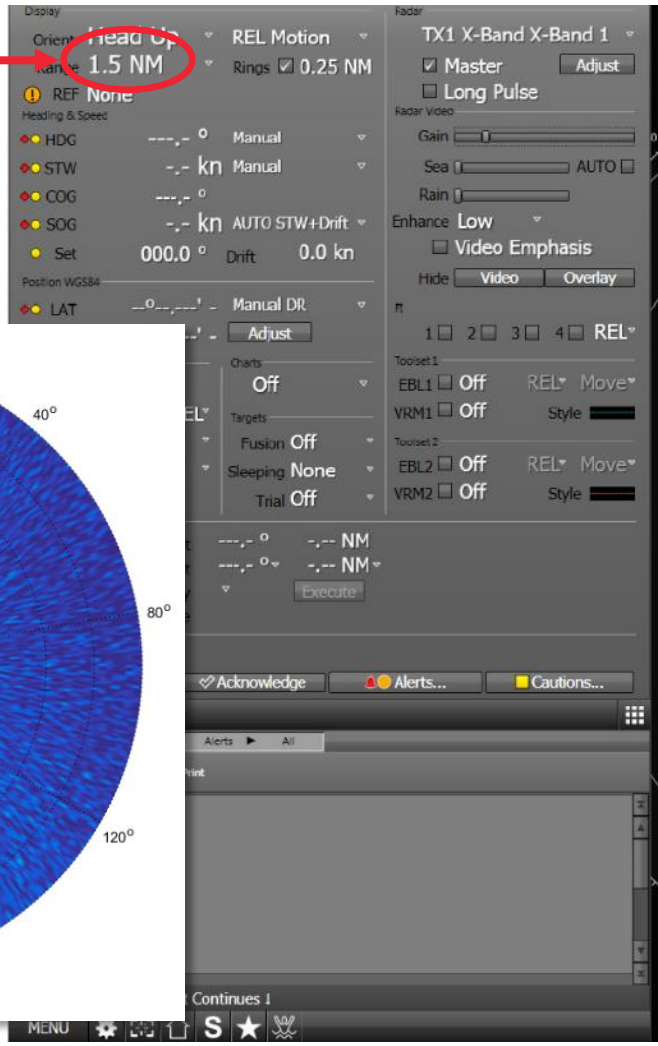


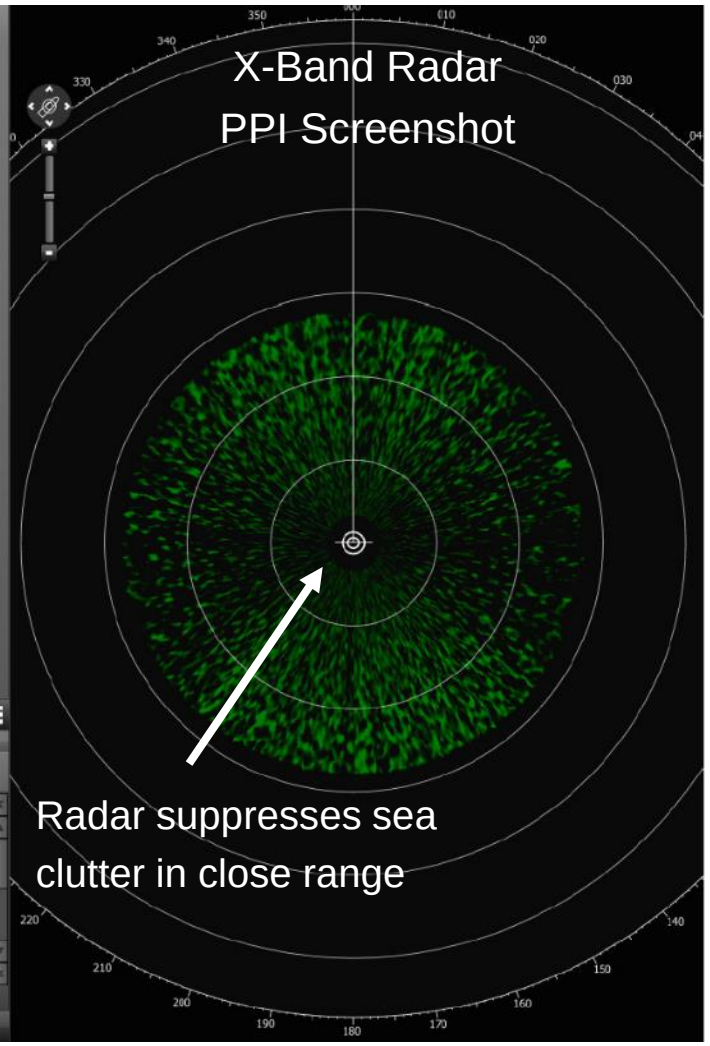
Simulated Sea Clutter

Max range
set to 1.5NM

Simulation

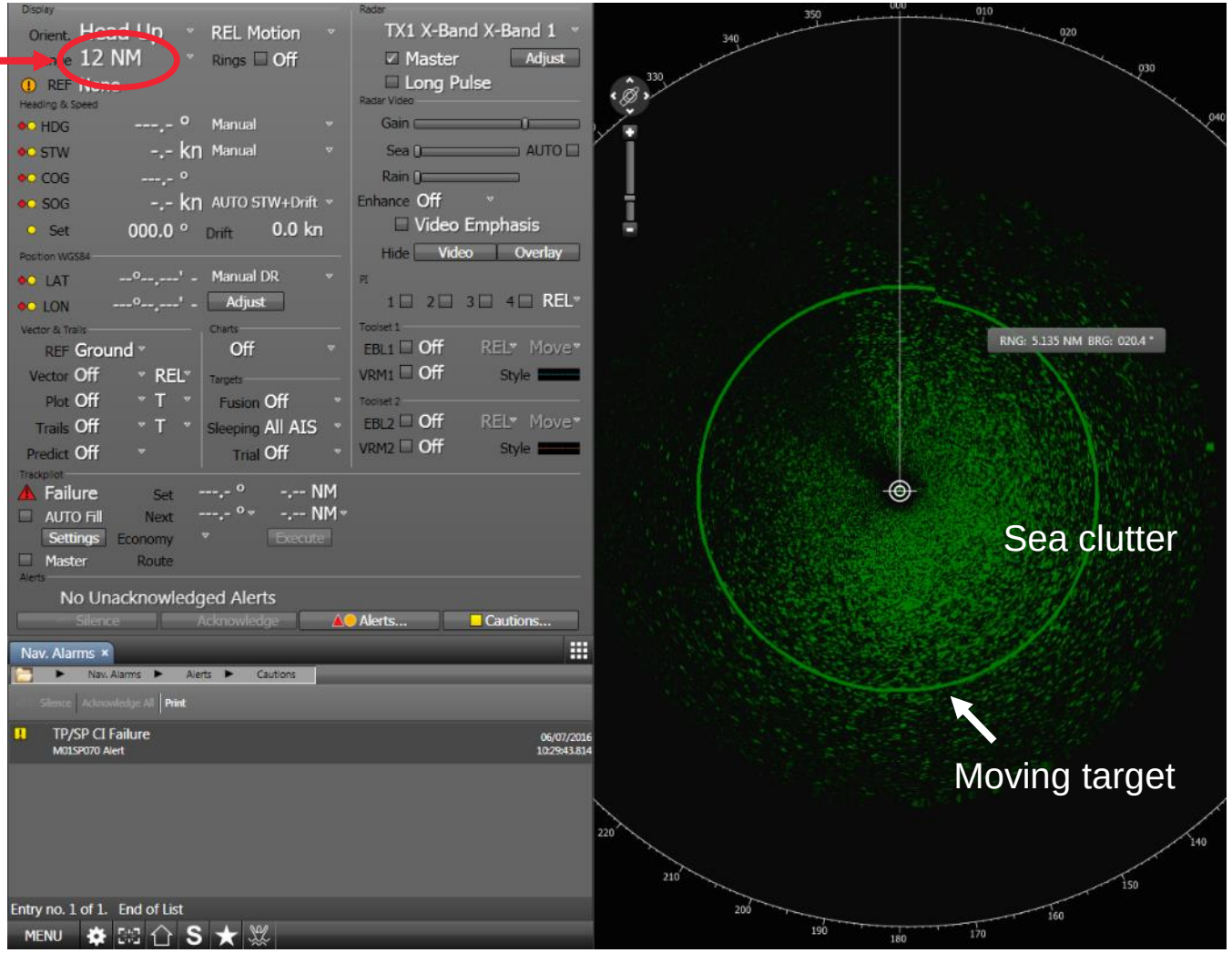






Recorded Sea Clutter

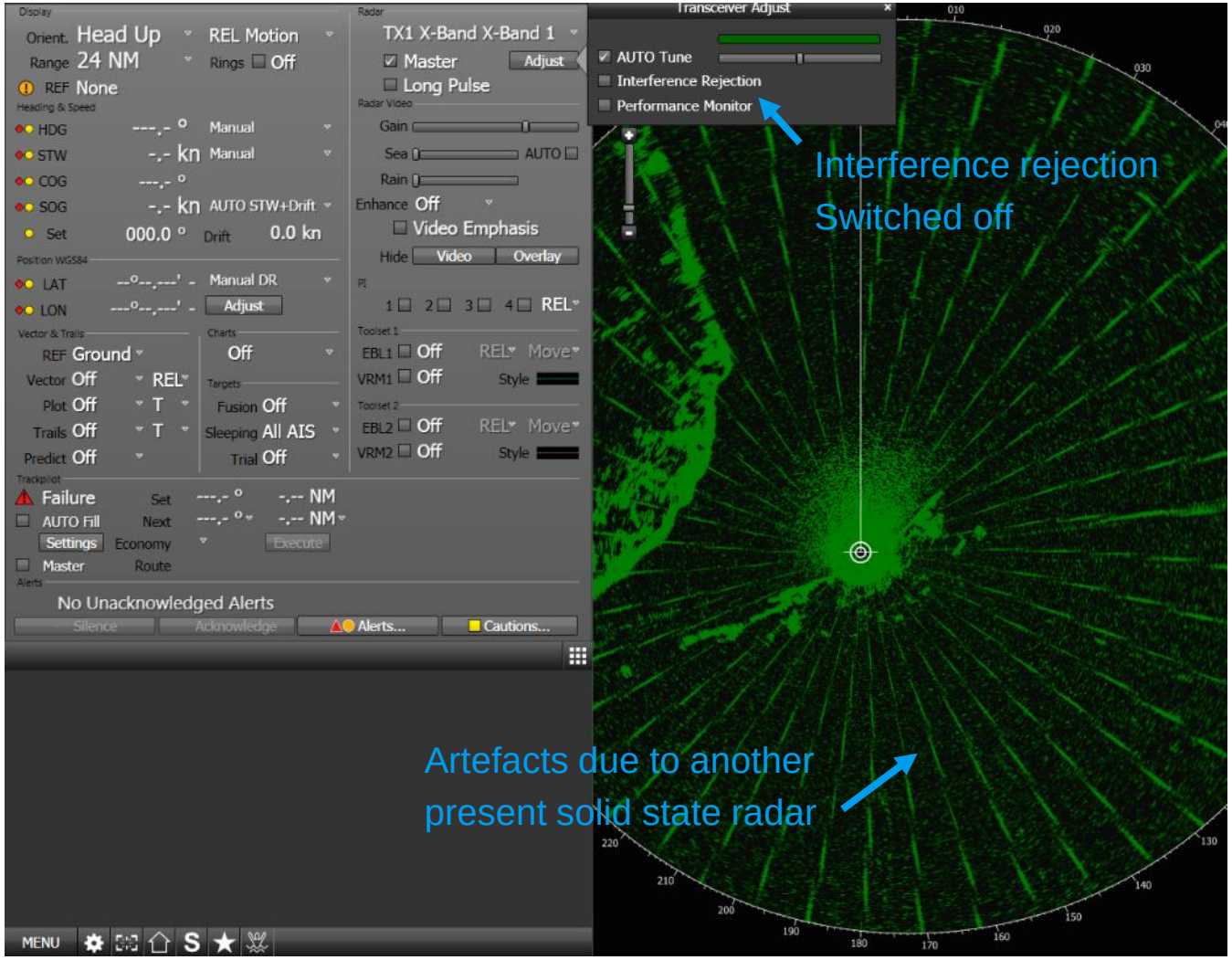
Max range set to 12NM

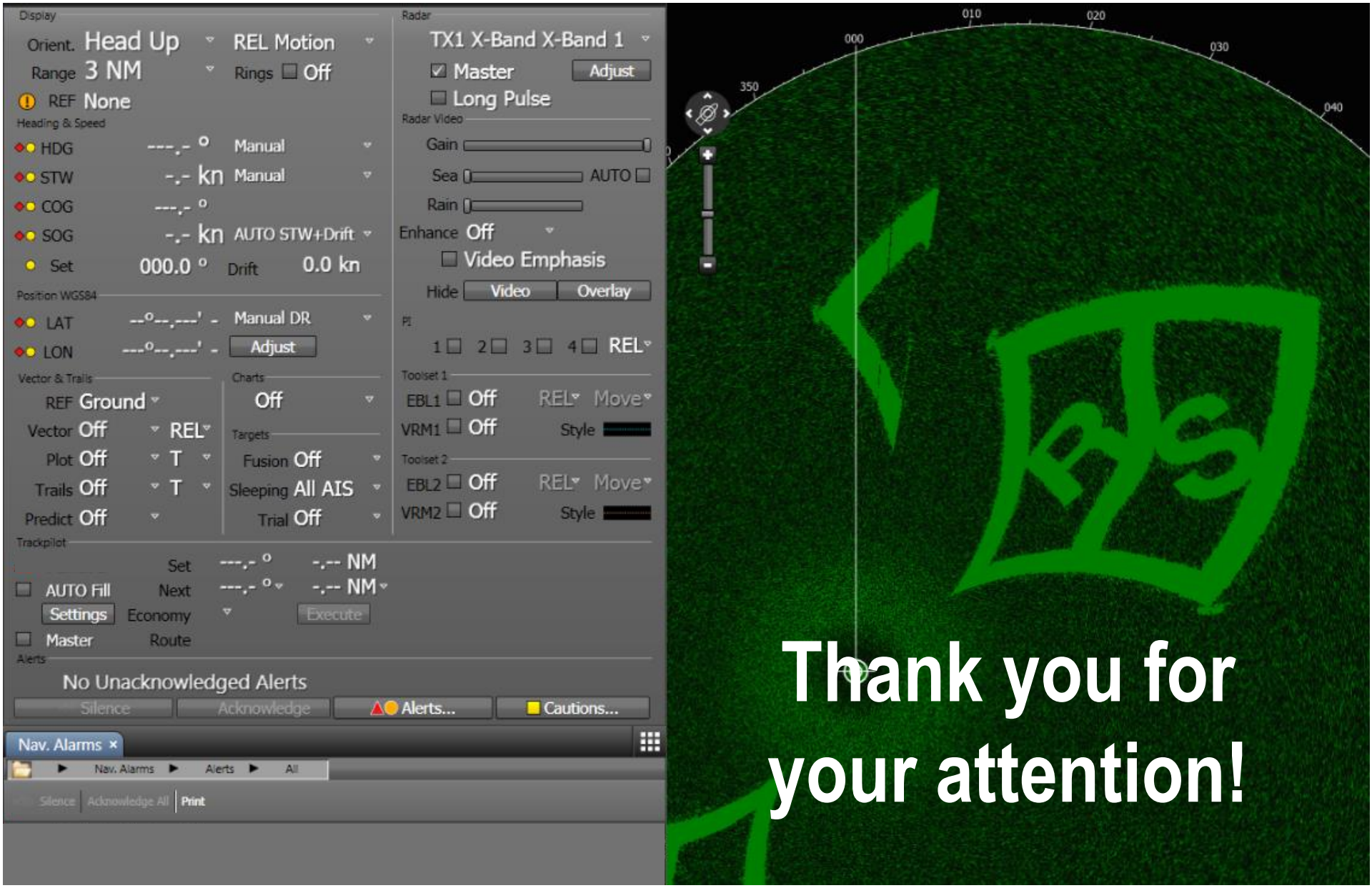


- Single radar echo signal, moving target with 100m/s in 5NM range
- Recorded sea clutter

Test of Interference Rejection

- Coastline
- Sea clutter in close range
- R&S®Pulse Sequencer Software to add interference / jamming signals
- Verify interference rejection




Display
Orient. Head Up
REL Motion
Range 3 NM
Rings Off
REF None
Heading & Speed
HDG ---.- °
Manual
STW -.- kn
Manual
COG ---.- °
SOG -.- kn
AUTO STW+Drift
Set 000.0 °
Drift 0.0 kn
Position WGS84
LAT --°--.---' -
Manual DR
LON ---°--.---' -
Adjust
Vector & Trails
REF Ground
Vector Off
REL
Plot Off
T
Trails Off
T
Predict Off
Charts
Off
Targets
Fusion Off
Sleeping All AIS
Trial Off
Trackpilot
Set ---.- ° -.-- NM
AUTO Fill
Next ---.- ° -.-- NM
Settings
Economy
Execute
Master
Route
Alerts
No Unacknowledged Alerts
Silence
Acknowledge
Alerts...
Cautions...
Nav. Alarms
Nav. Alarms ▶ Alerts ▶ All
Silence
Acknowledge All
Print
Radar
TX1 X-Band X-Band 1
Master
Adjust
Long Pulse
Radar Video
Gain
Sea
AUTO
Rain
Enhance Off
Video Emphasis
Hide
Video
Overlay
PI
1 2 3 4 REL
Toolset 1
EBL1 Off
REL
Move
VRM1 Off
Style
Toolset 2
EBL2 Off
REL
Move
VRM2 Off
Style
010
020
000
030
350
040
Thank you for your attention!