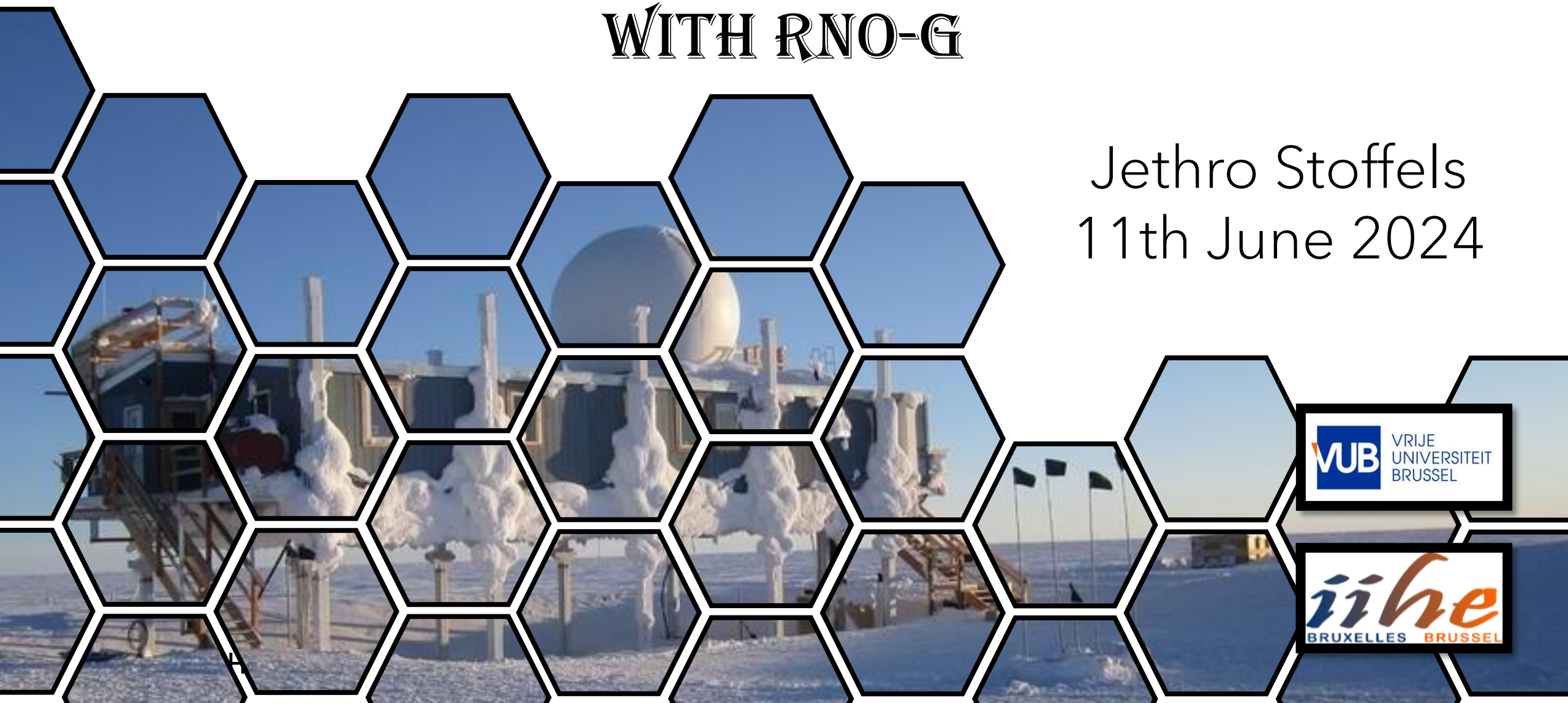
Observation of Galactic Noise and Identification of Background Sources with RNO-G



Jethro Stoffels

11th June 2024

VUB VRIJE UNIVERSITEIT BRUSSEL

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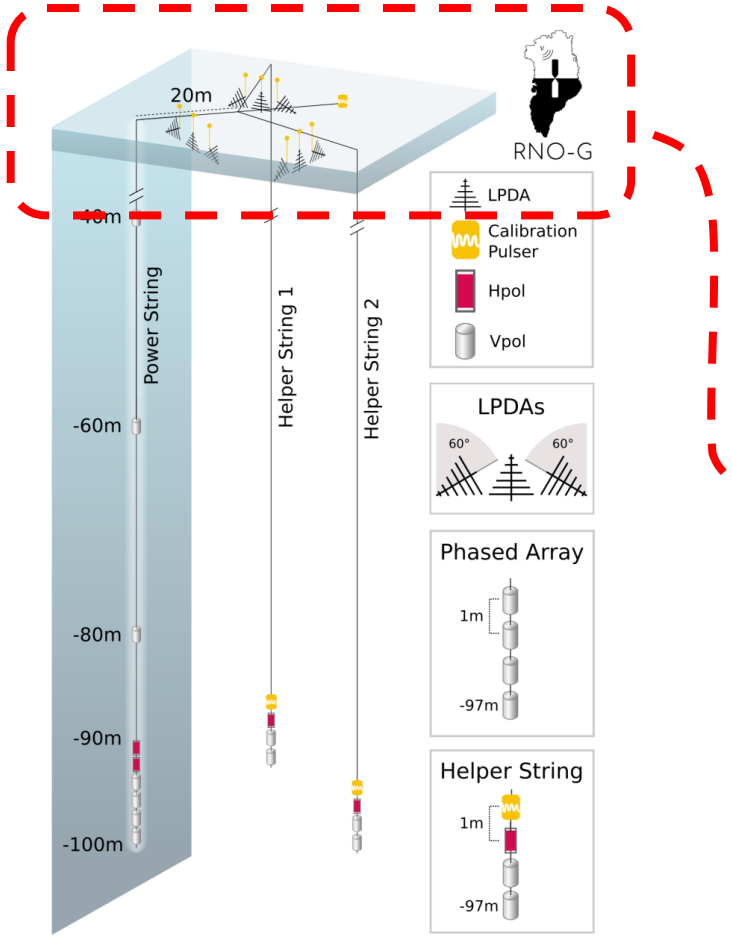
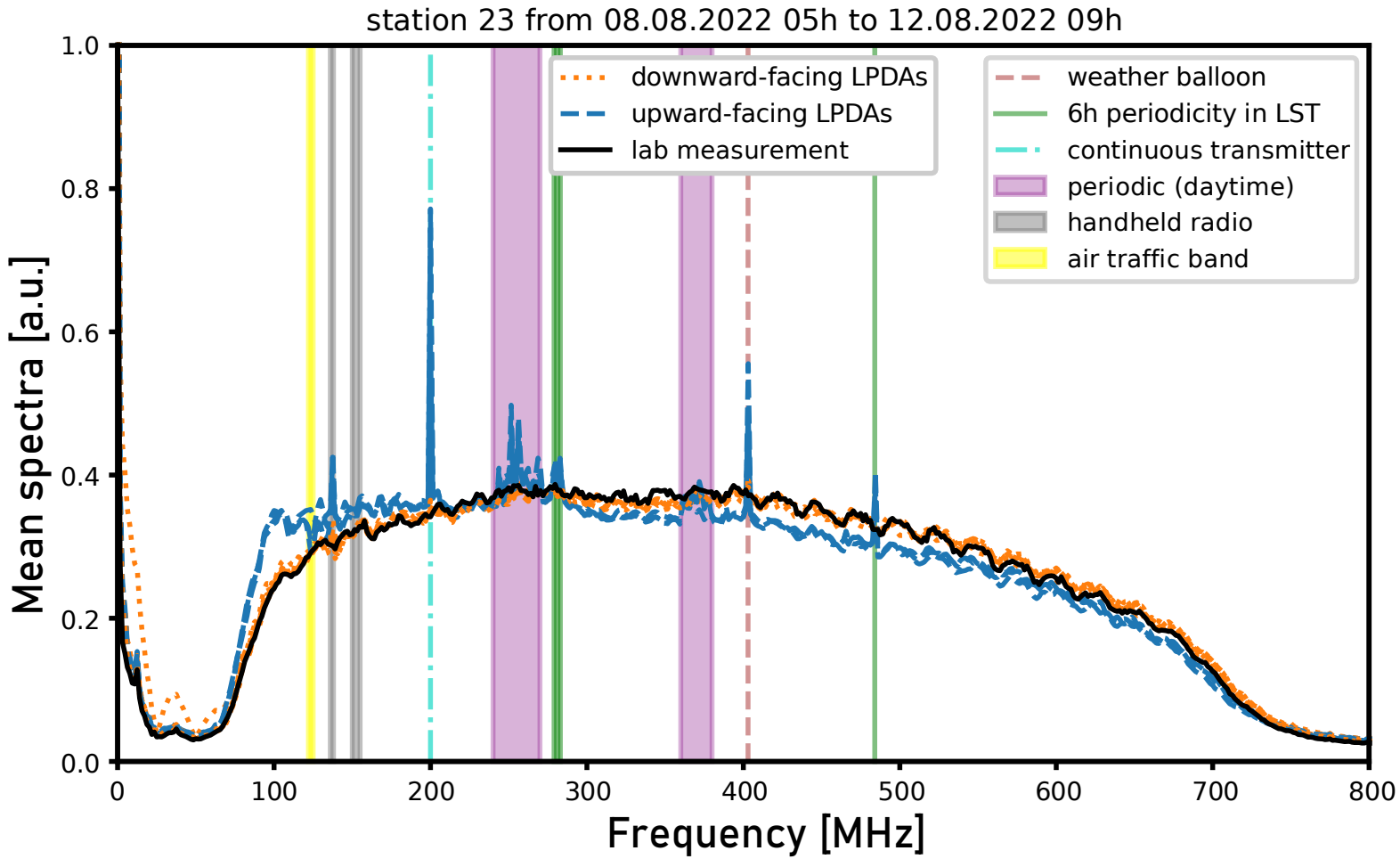
INTRODUCTION

LPDA spectrum contributions





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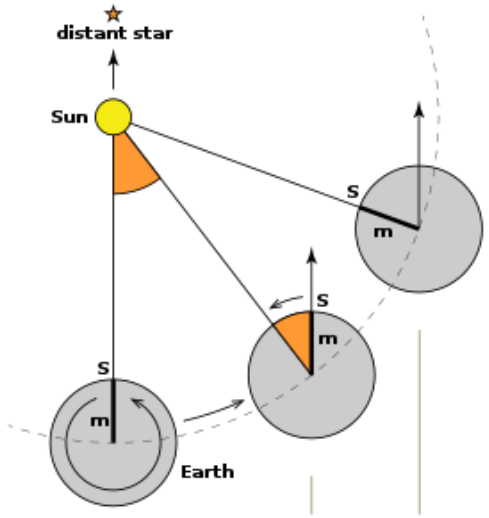
GALACTIC NOISE

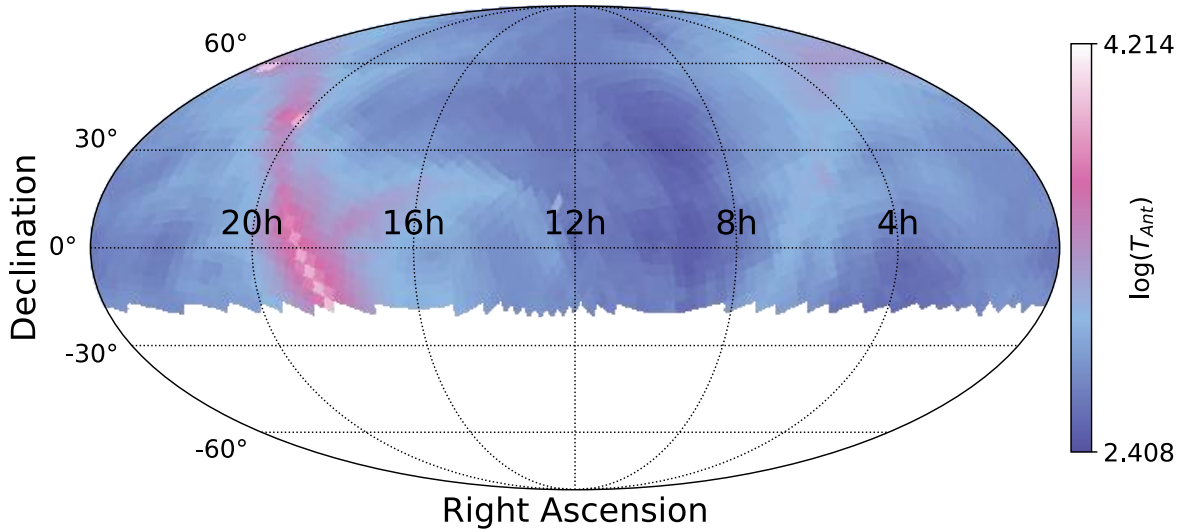
Concept

- V_{RMS} of timetraces VS Local Sidereal Time (LST)

- LST instead of LT ⇒ General noise averages out

- For RNO-G:
  - Visibility from Summit Station
  - Use the three upwards facing surface antennas with background data
  - Dataset: Jun-2022 to Aug-2022

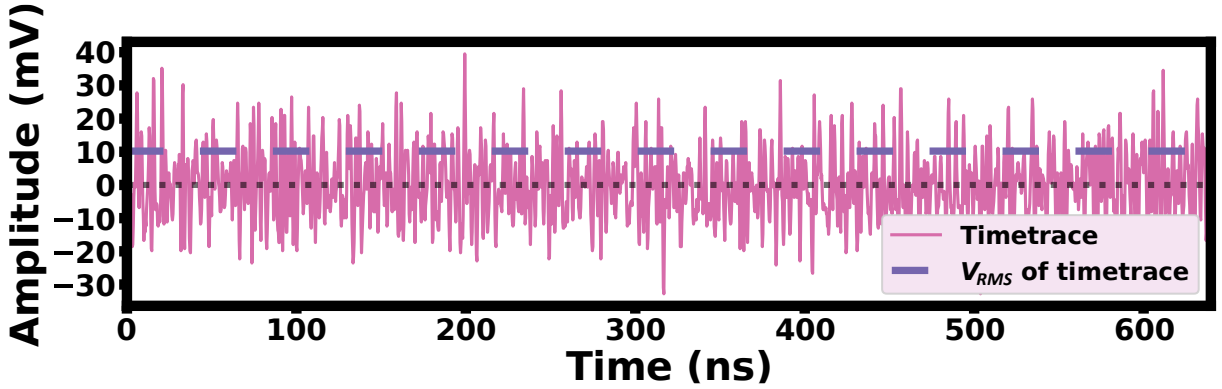




GALACTIC NOISE

Approach

- Definition: $V_{RMS} = \sqrt{\frac{1}{N}\sum_i (V_i - \langle V \rangle)^2}$



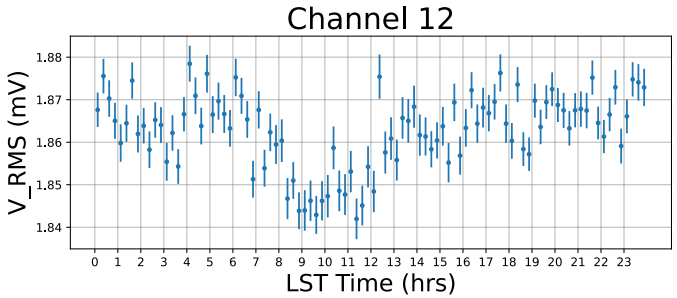
- Bins VRMS values based on LST time

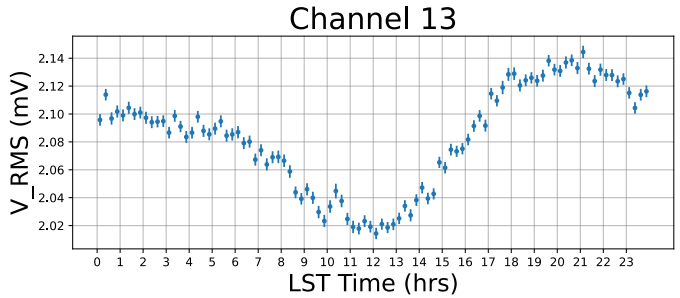
- Data cleaning:
  - Filtering galactic dominant region (<110MHz)
  - Two quality cuts @ 3σ

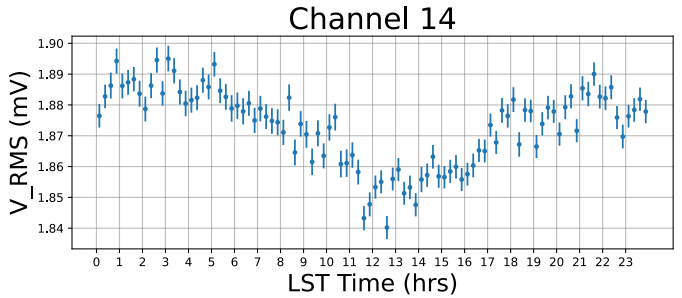
- NuRadioMC Simulation:
  - Instrumental noise: $V_{RMS} = \sqrt{Rk_bT\Delta\nu}$
  - Galactic: pydgsm package → radio sky model → galactic noise @ antenna

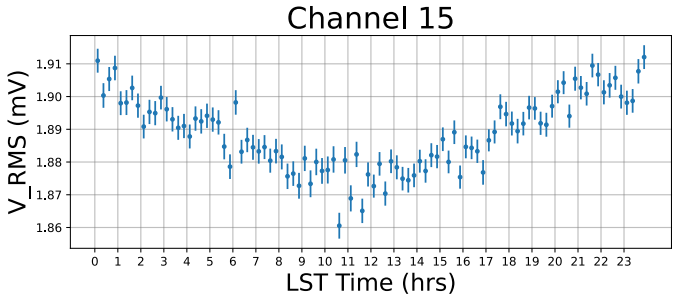
GALACTIC NOISE

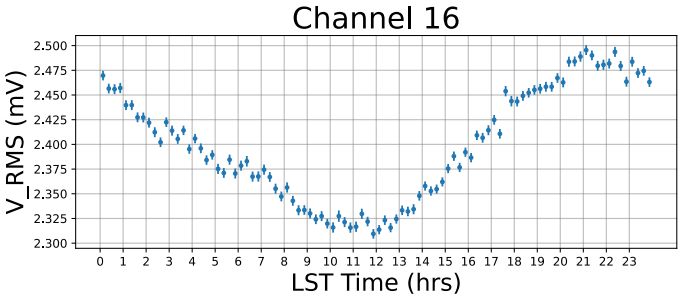
Transit curve summary station 23

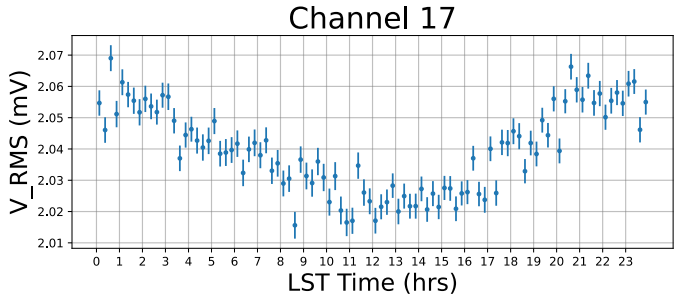


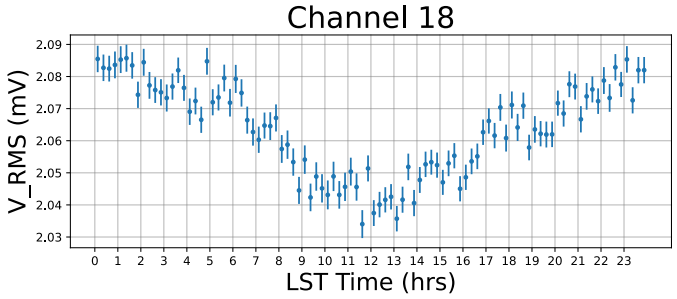


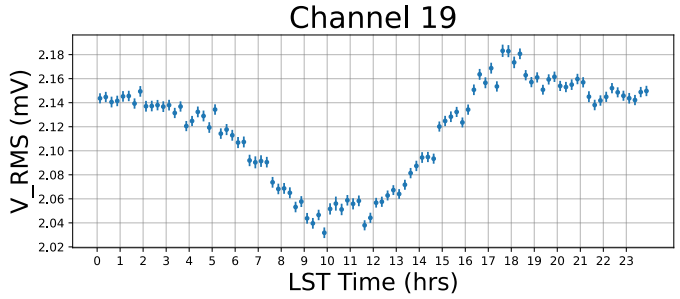


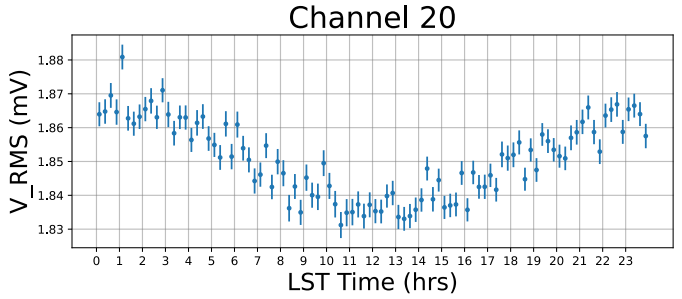












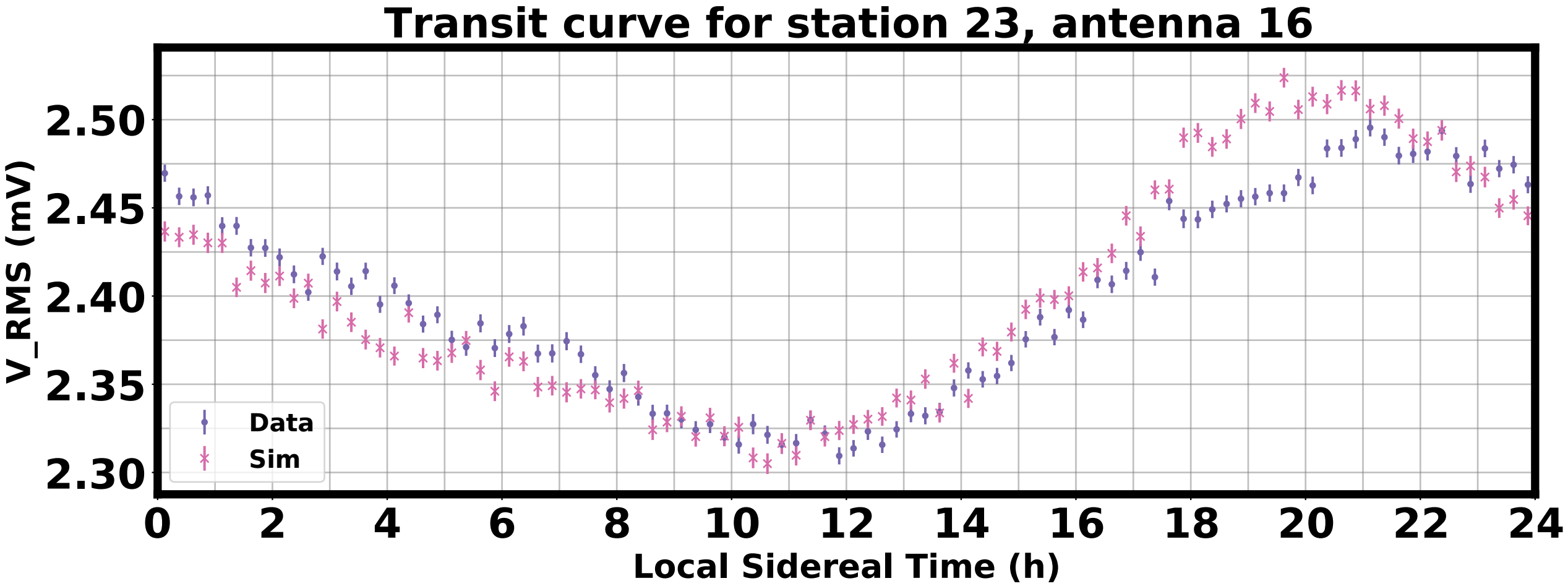
Downwards facing LPDAs

Upwards facing LPDAs

Downwards facing LPDAs

GALACTIC NOISE

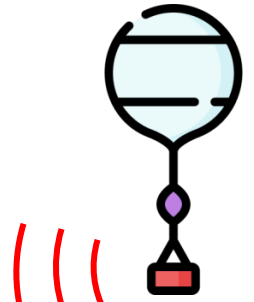
Simulation VS data

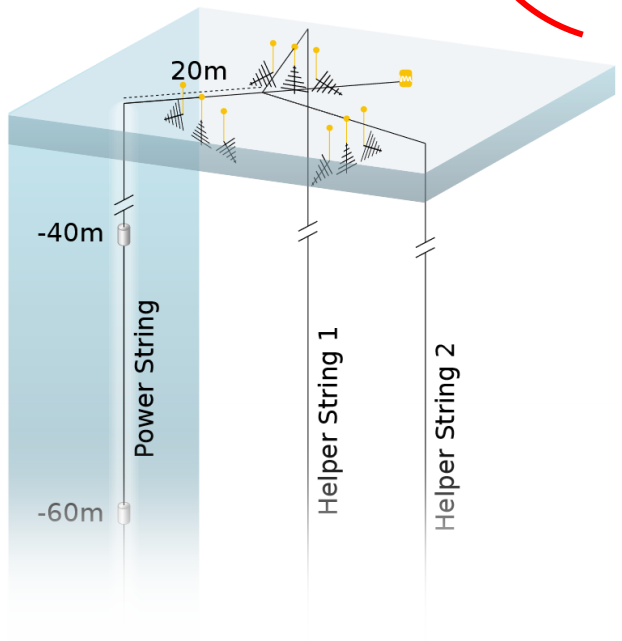


ANTHROPOGENIC NOISE

Classes

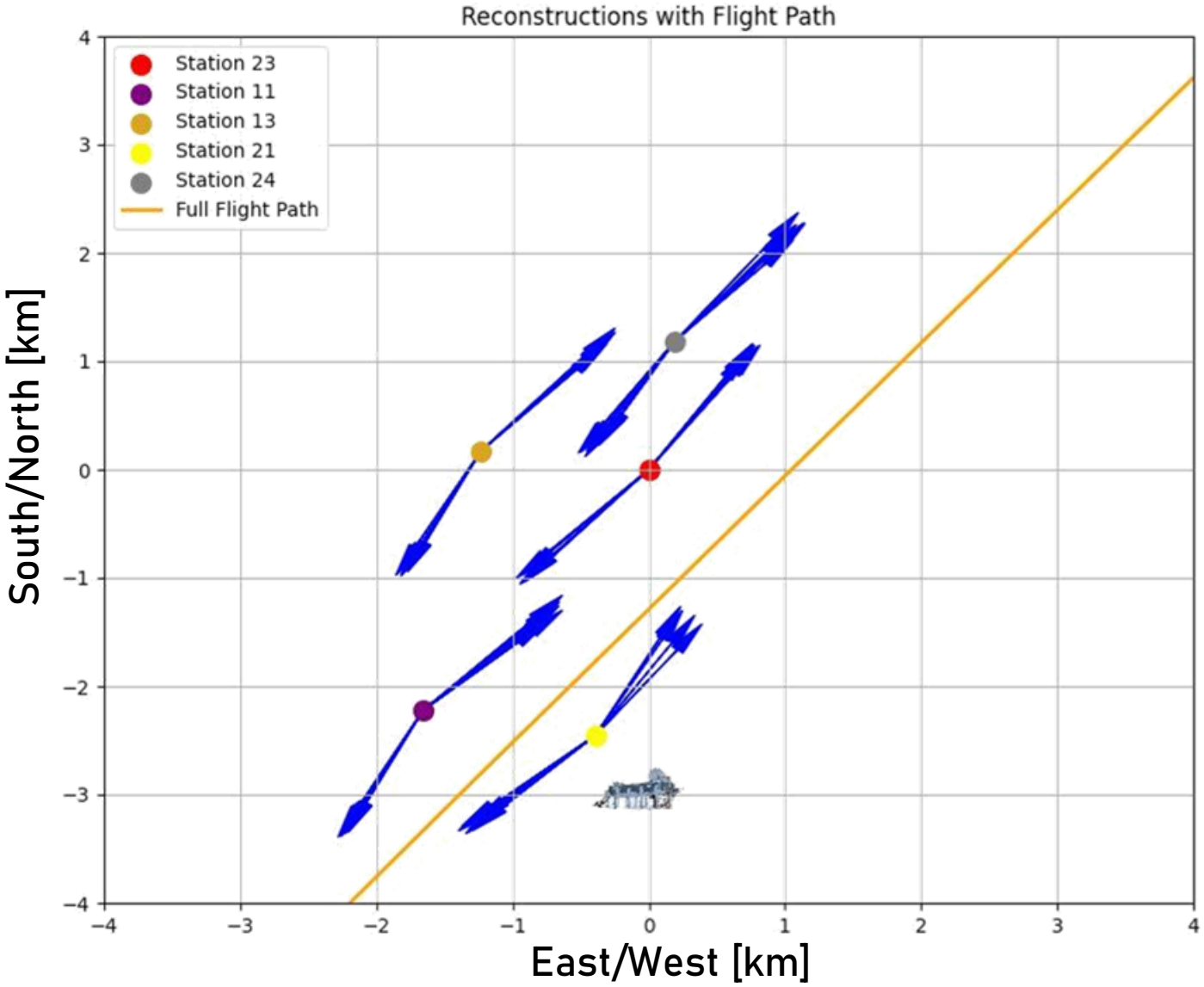
- Weather balloon
- Planes
- Station activity:
  - Communication equipment
  - Snowmobile
  - Heavy machinery
  - 200MHz continuos wave (CW) line
- Wind turbines





ANTHROPOGENIC NOISE

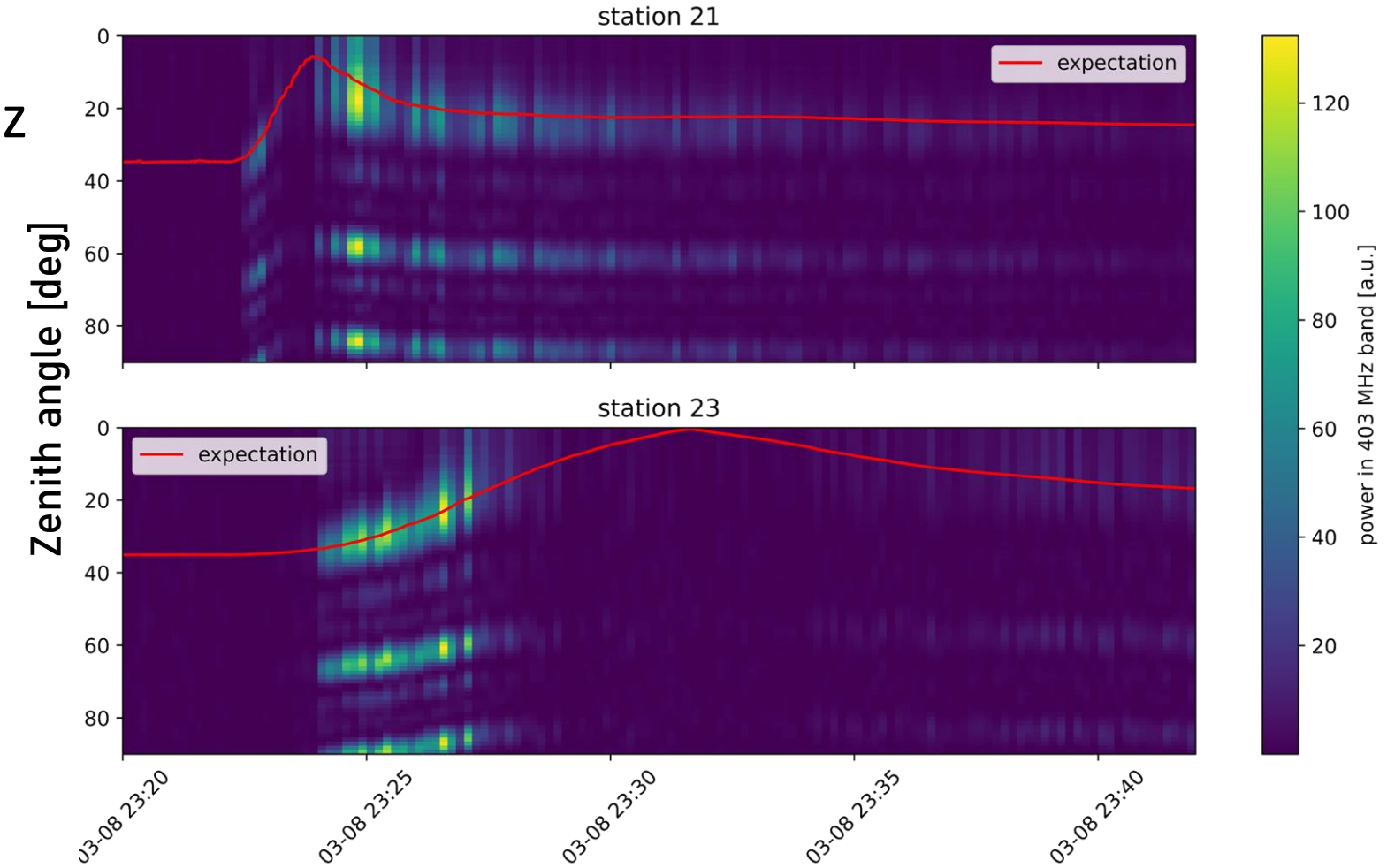
Planes



ANTHROPOGENIC NOISE

Weather balloon

- Weather balloon:
  - Transient CW at 403MHz
  - Reconstructible via phased array
  - Measurement of refractive index



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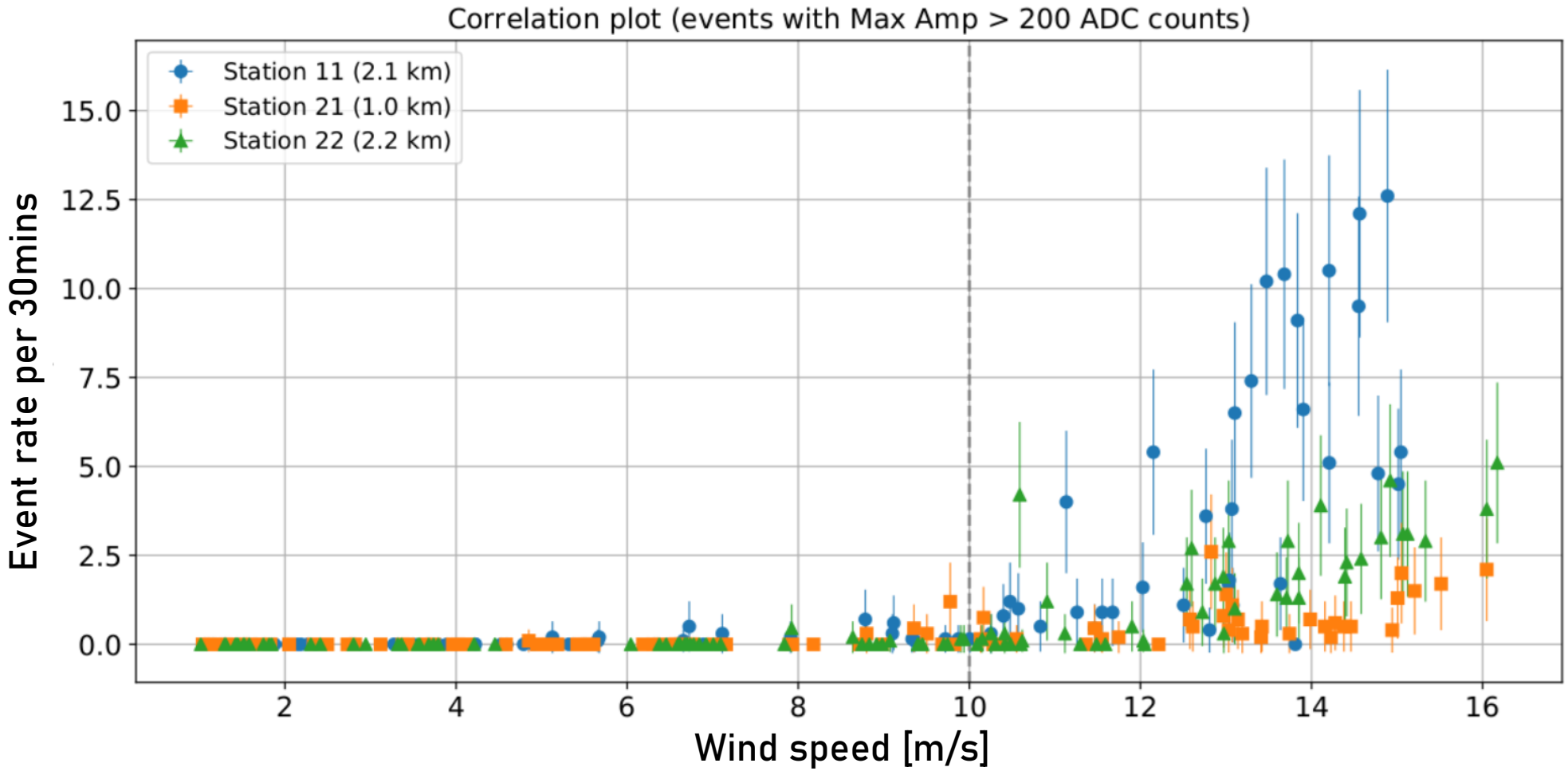
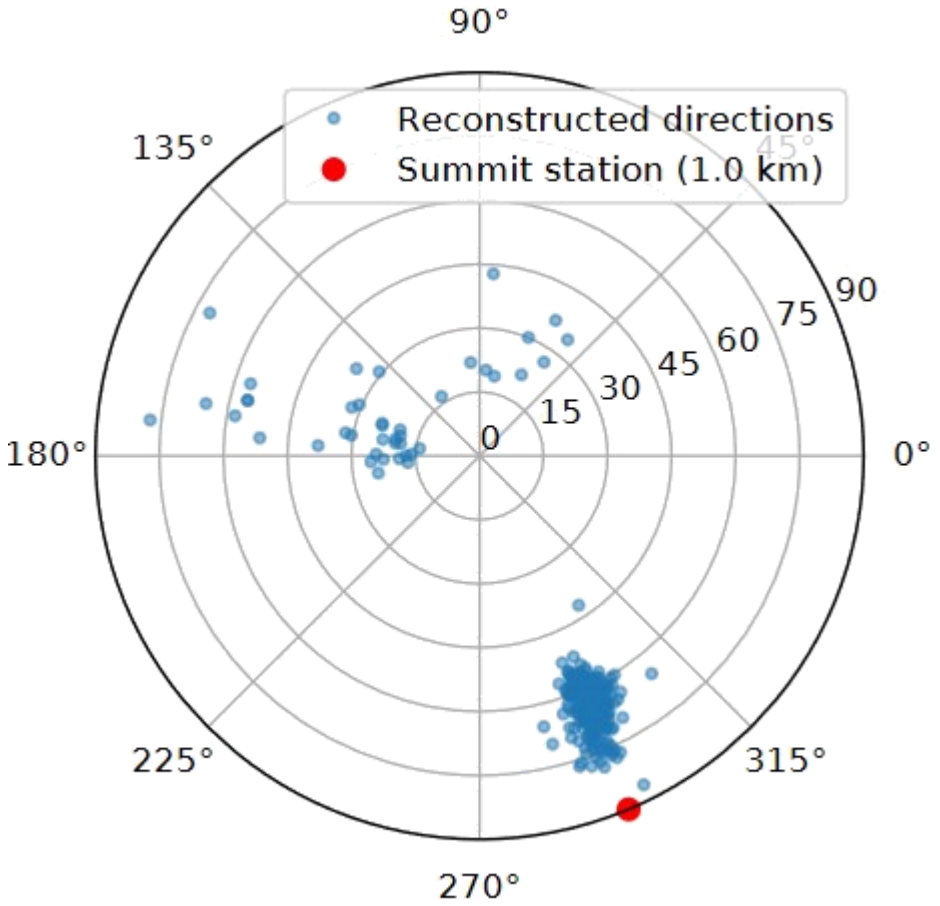
Windy periods

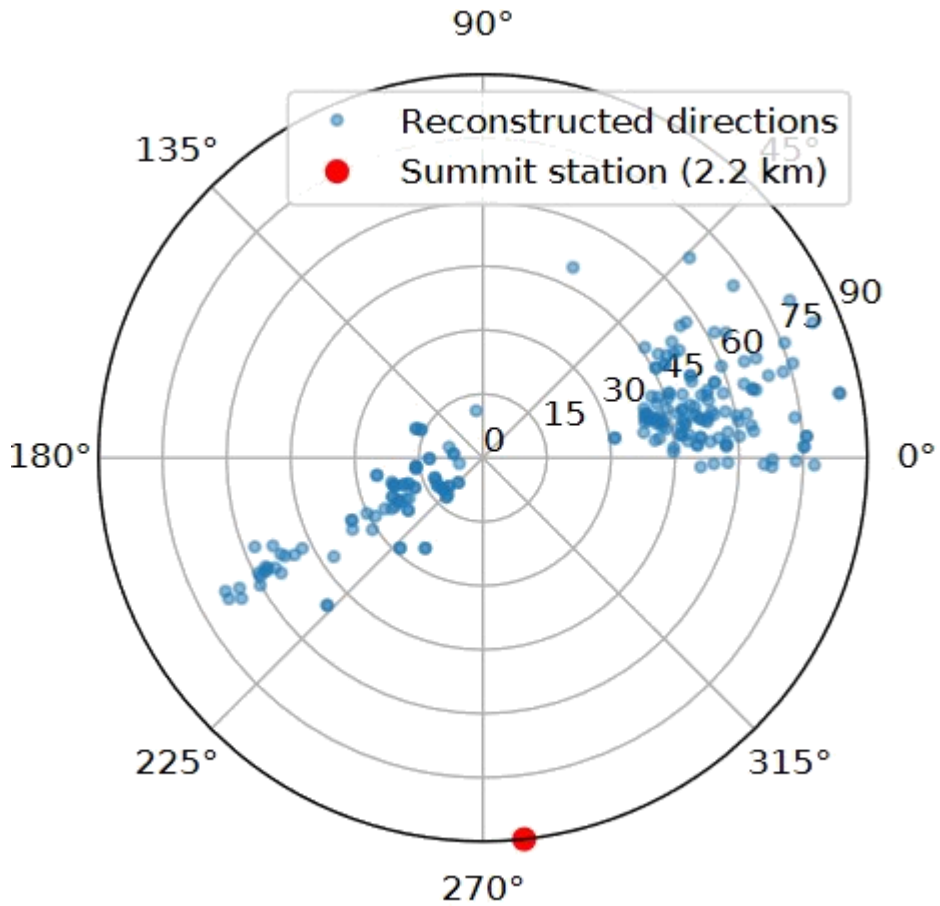


[J. A. Aguilar et al. Astroparticle physics 145 (2023): 102790]

Reconstruction windy periods



Station 21

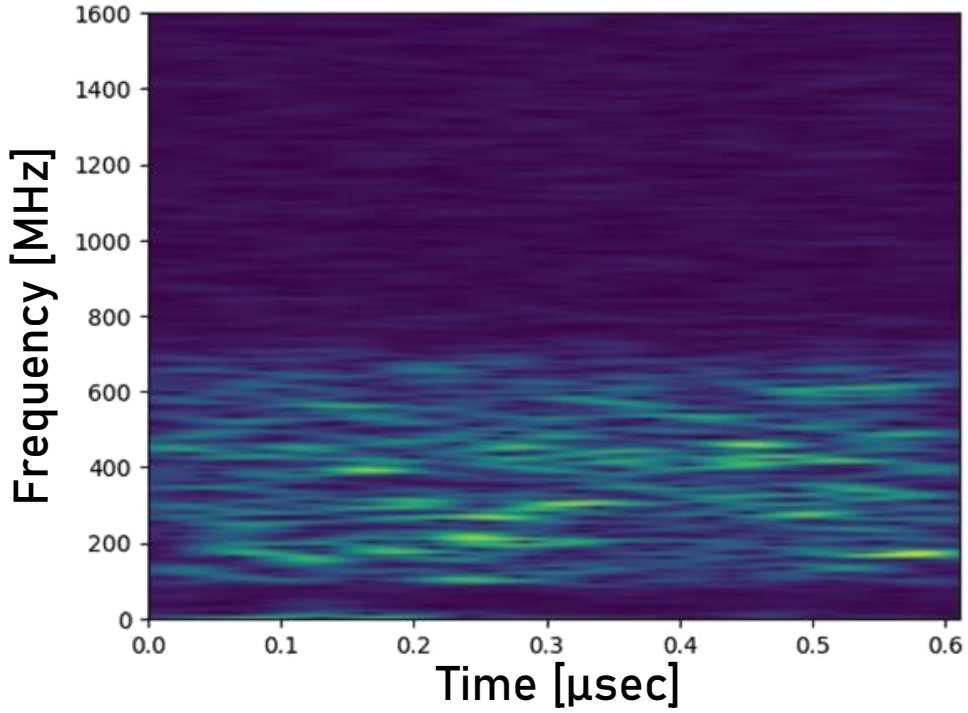


Station 22

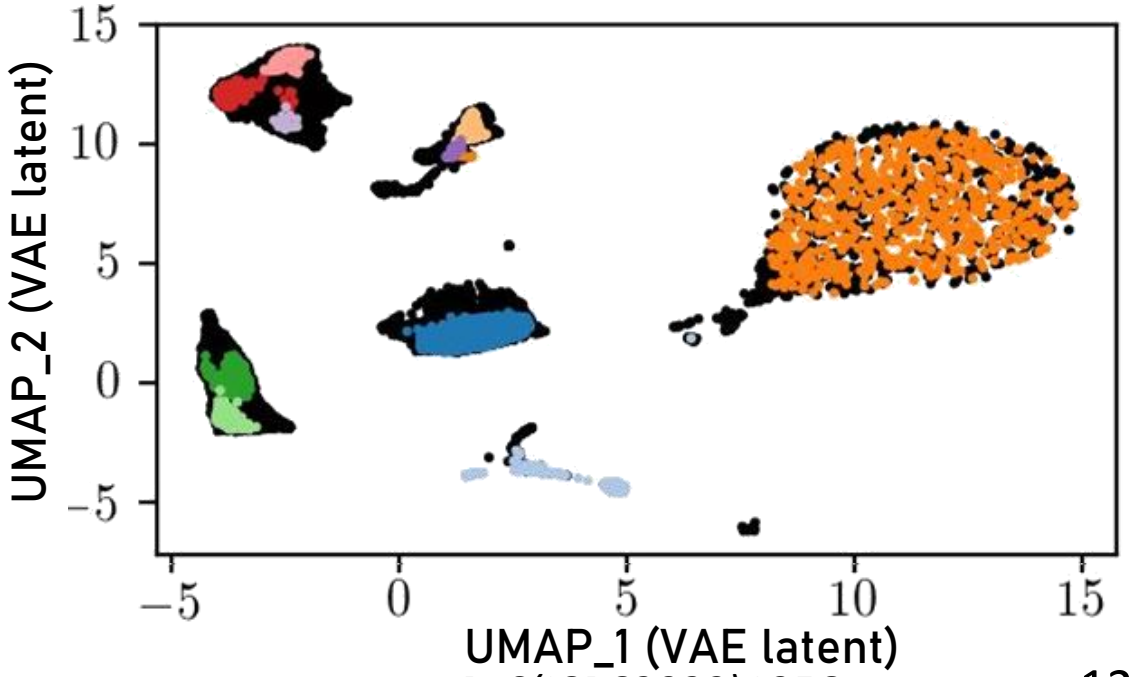
[J. A. Aguilar et al. Astroparticle physics 145 (2023): 102790]

Analyses developments

- Anomaly detection:
  - Train network on spectrograms
  - Separates non-background events



- Data classification:
  - Two step process:
    1) Variational autoencoder
    2) Clustering in latent space



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PoS(ICRC2023)1056

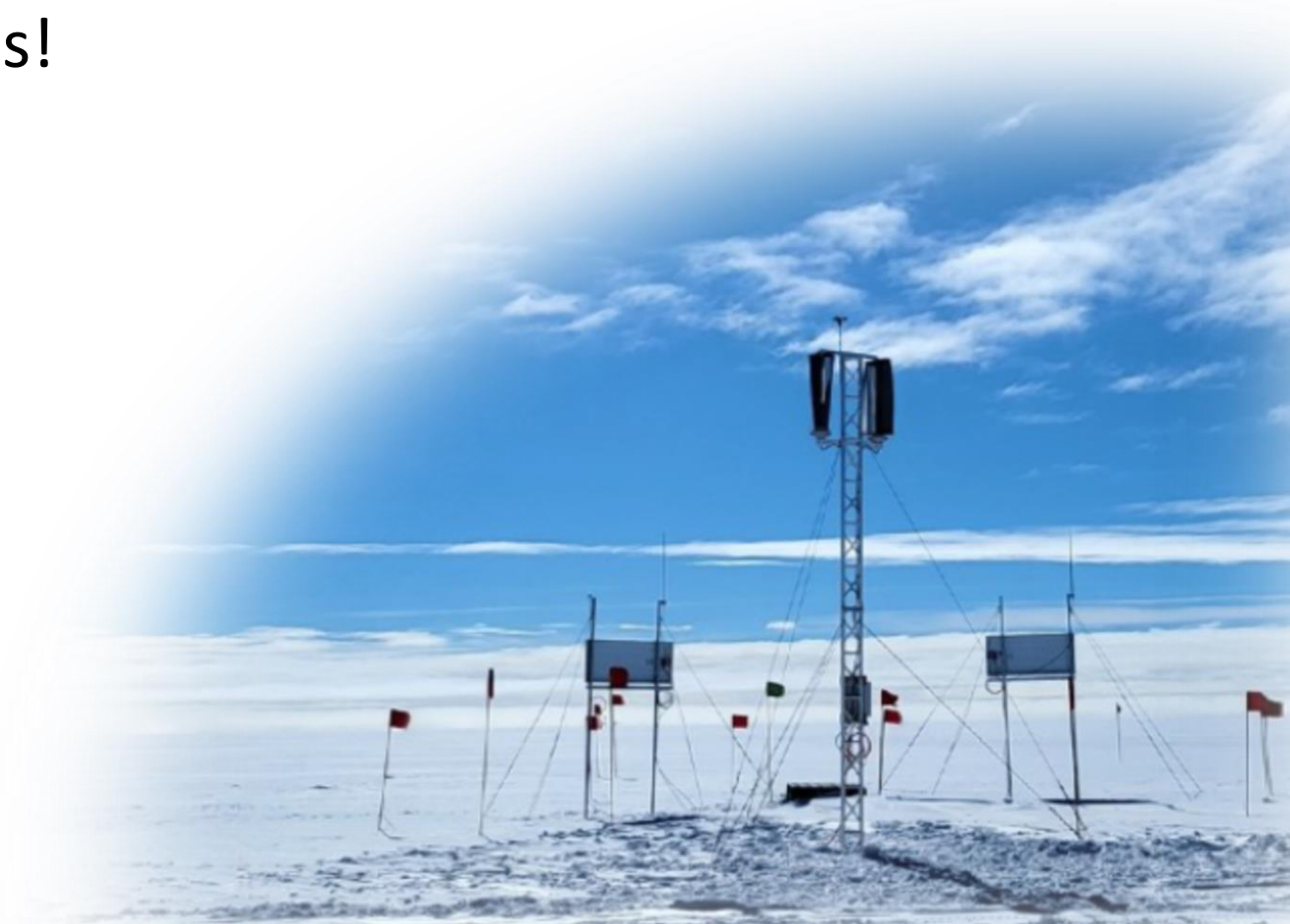
SUMMARY

- RNO-G:
  - 35 Stations (seven installed) => 3 summers of data
  - Need to understand backgrounds!

- Observed backgrounds:
  - Thermal - Anthropogenic
  - Galactic - Environmental

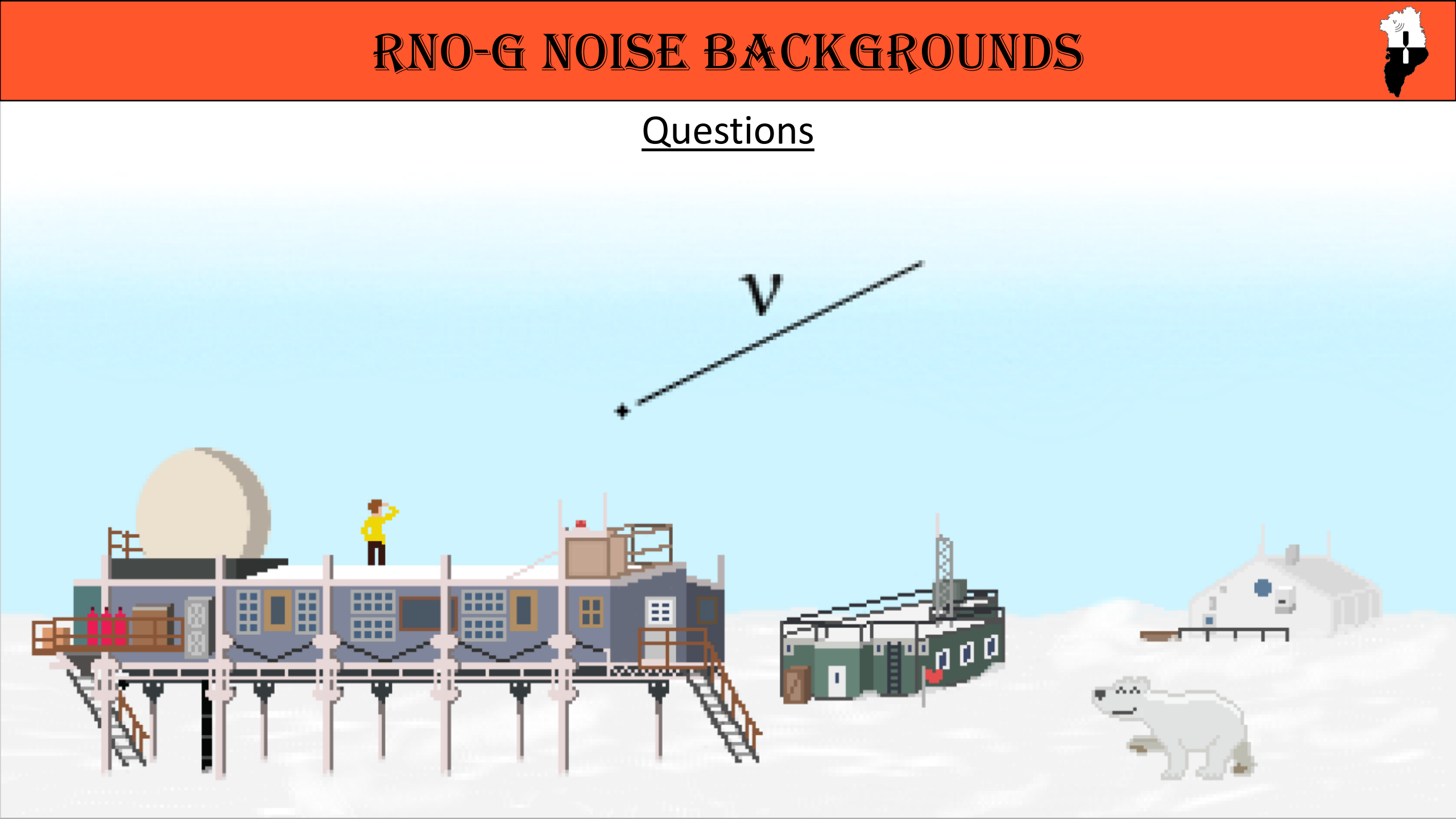
- Backgrounds used for calibration

- Classification & anomaly detection
  => real time tools



RNO-G NOISE BACKGROUNDS

Questions



BACK-UP

Classes

- Weather balloon:
  - Transient continues wave (CW) at 403MHz
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  - Measurement of refractive index
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  - Heavy machinery
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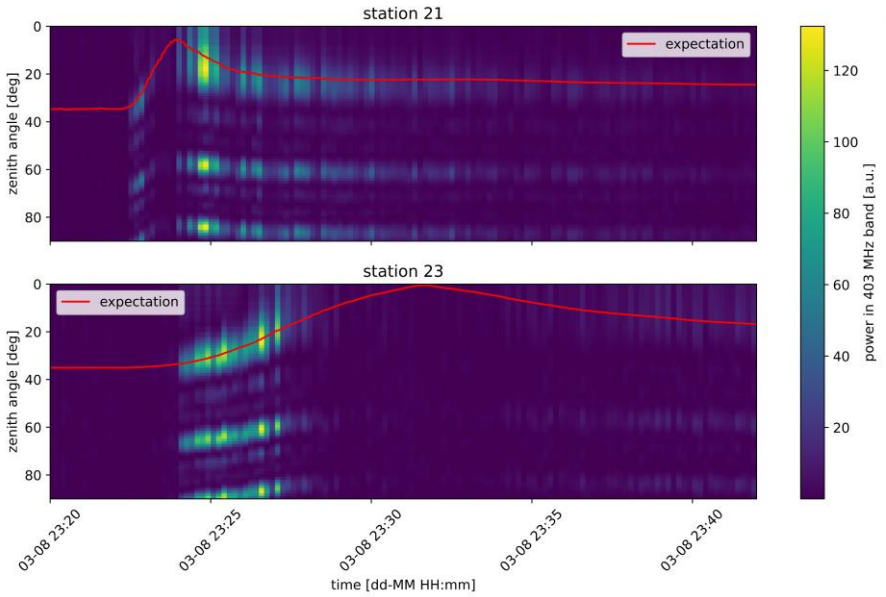
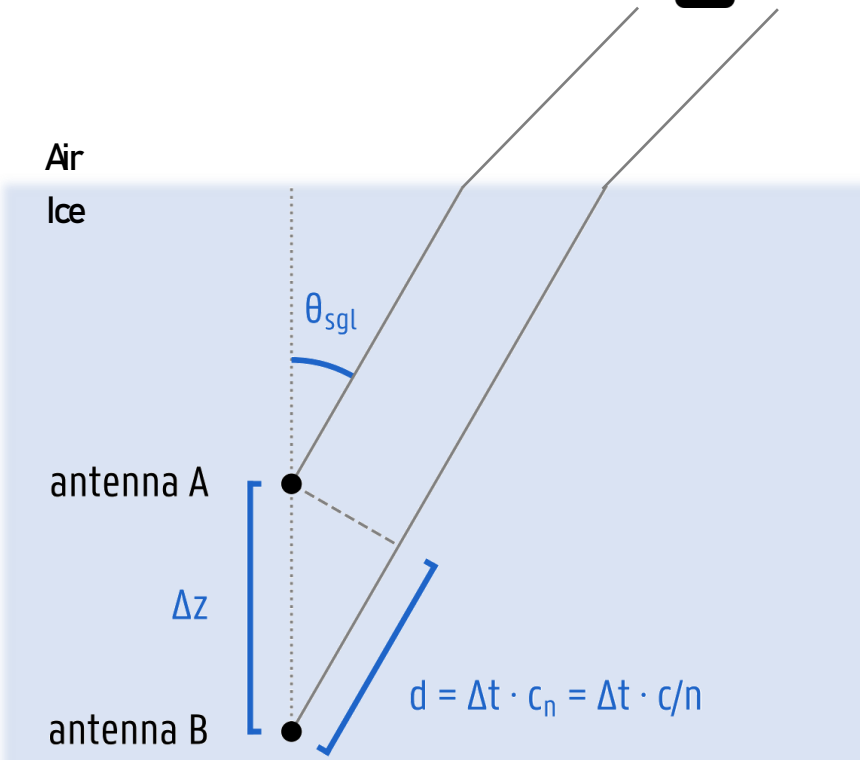


Credits: Steffen Hallman, DESY



Credits: Bob Oeyen, UGent

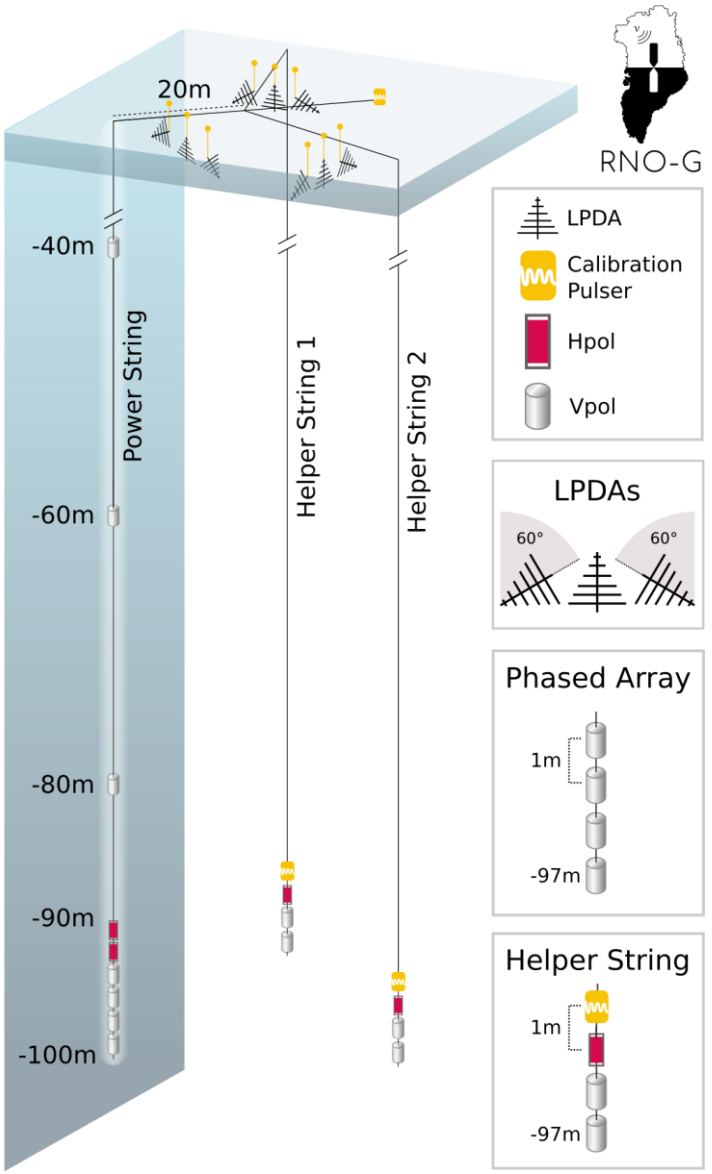
BACK-UP

RNO-G

- 24 antennas/station
  => 9 surface antennas
  => 16 in-ice antennas

- Solar powered
  => 7 months operational
  => Wind power (WIP)

- 7 of the planned 35 stations installed
  => 3 summers of data



Channel Comparison

- Different signal strenghts/shapes
- Station 21 & 22 frequently grouped at bottom

- Potential culprit: hardware difference