

Status of the Radar Echo Telescope Experiment

Isha Loudon, on behalf of the Radar Echo Telescope
collaboration

02/09/26

TeVPA 2026



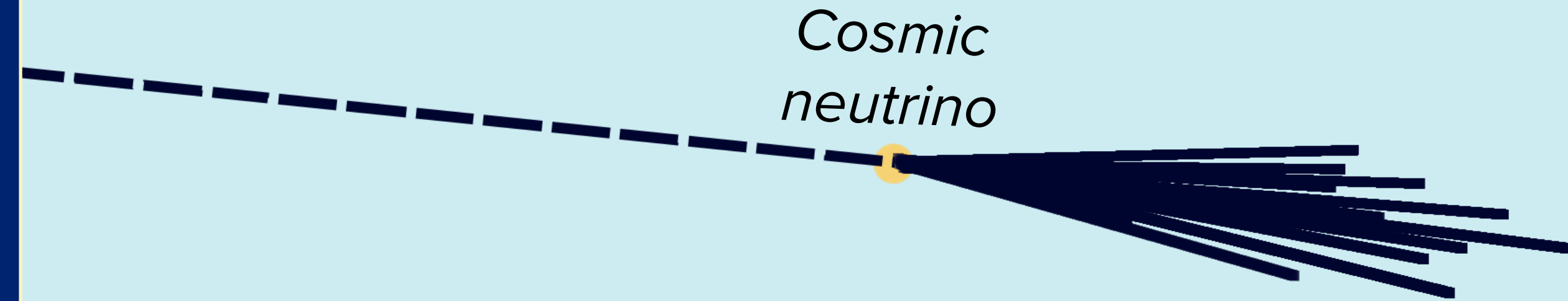
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>PeV Neutrino Astronomy

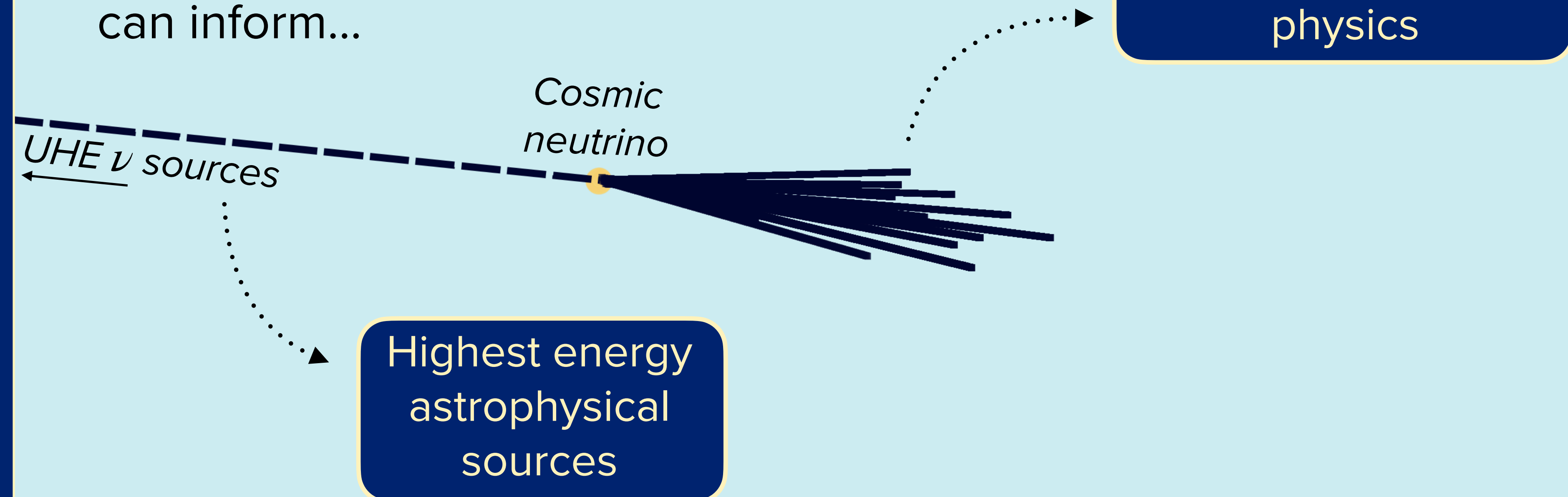
- Detections of cosmic neutrinos can inform...

*Cosmic
neutrino*



>PeV Neutrino Astronomy

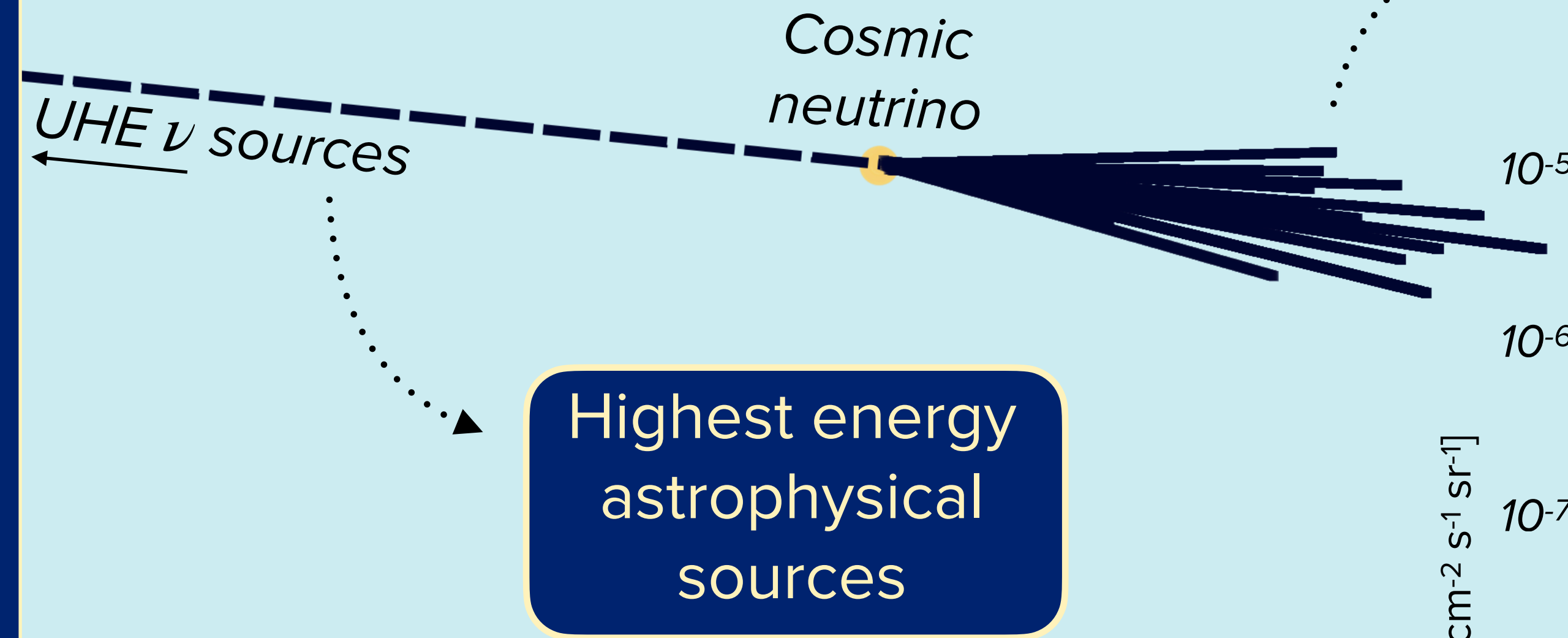
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>PeV Neutrino Astronomy

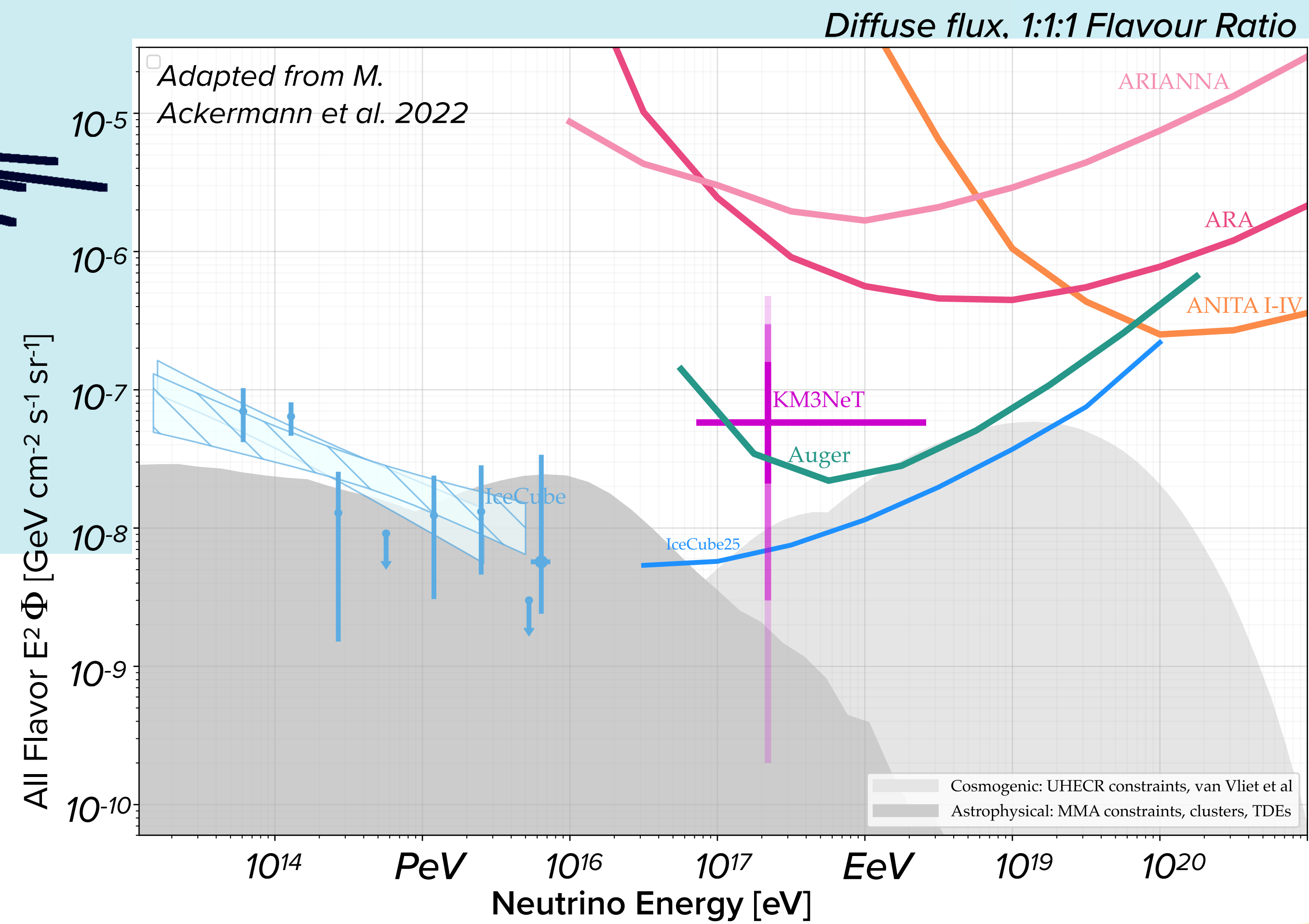
- Detections of cosmic neutrinos can inform...

Fundamental particle physics



Highest energy astrophysical sources

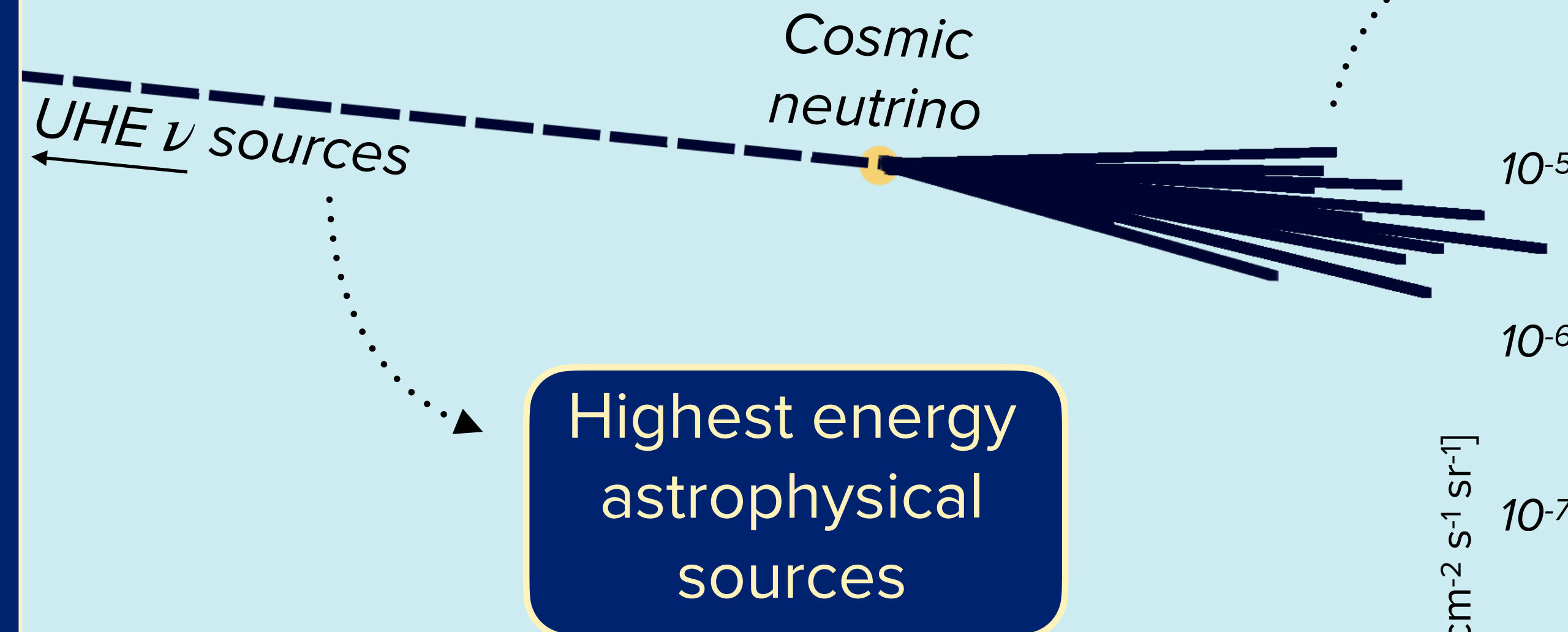
- Overcoming the lower ν flux at higher energies requires **new detection methods**



>PeV Neutrino Astronomy

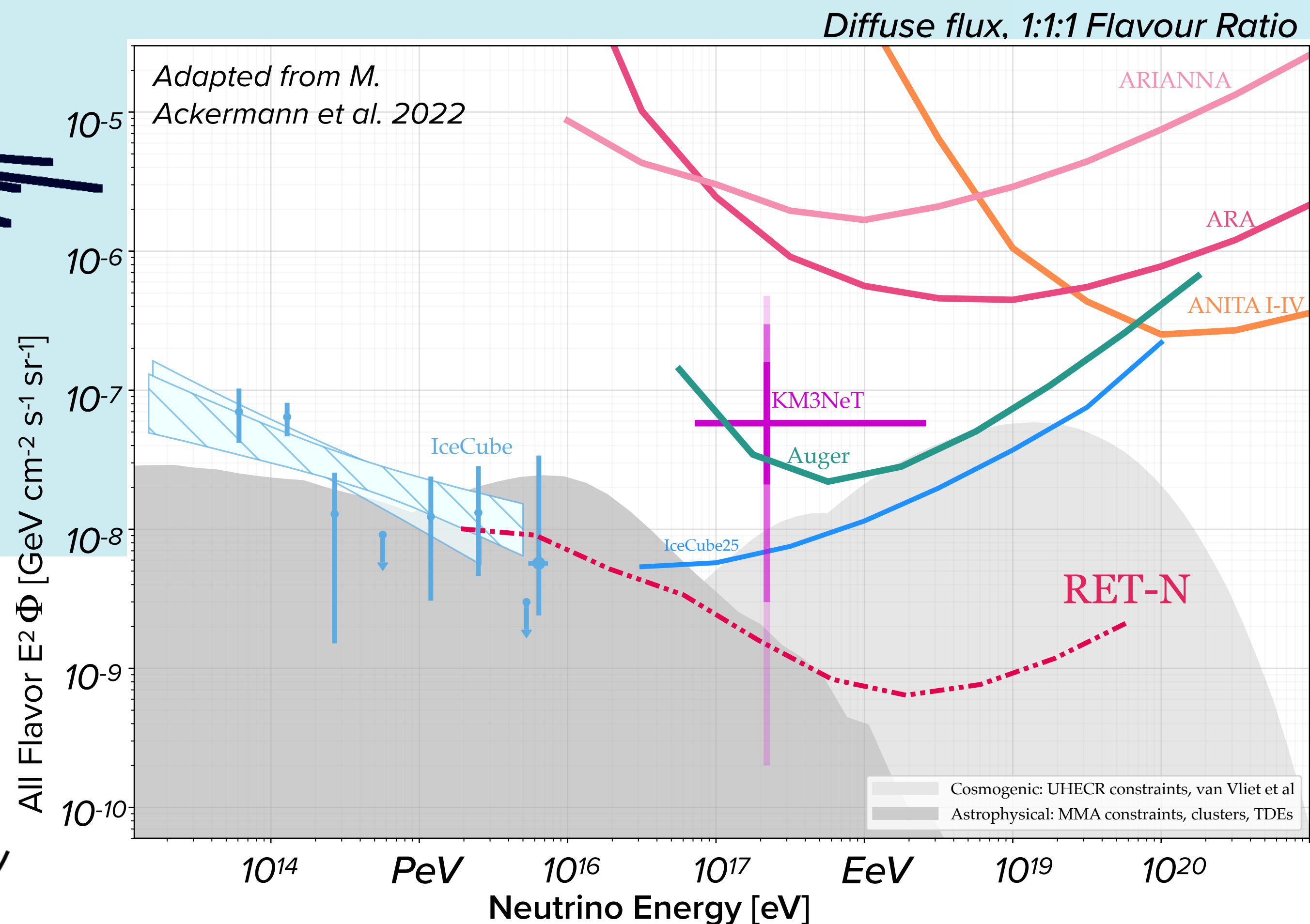
- Detections of cosmic neutrinos can inform...

Fundamental particle physics



- Overcoming the lower ν flux at higher energies requires **new detection methods**

→ RADAR ECHO TELESCOPE



Radar Detection of Astrophysical Particles

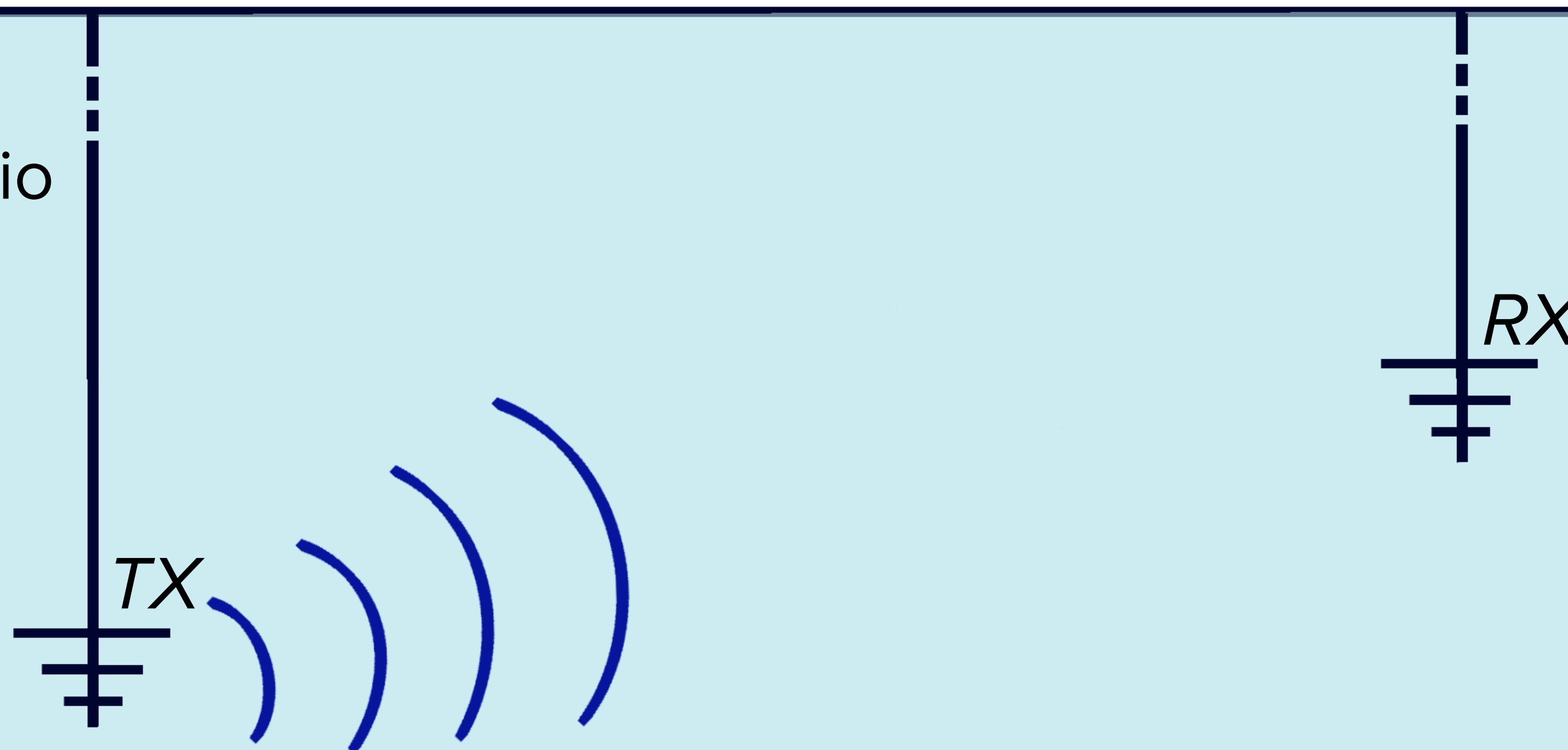
- ▶ High-energy particles interacting in ice produce **relativistic particle cascades**

*Cosmic
neutrino*

- ▶ The developing cascade leaves a **trail of ionisation** in its wake

Radar detection of astrophysical particles

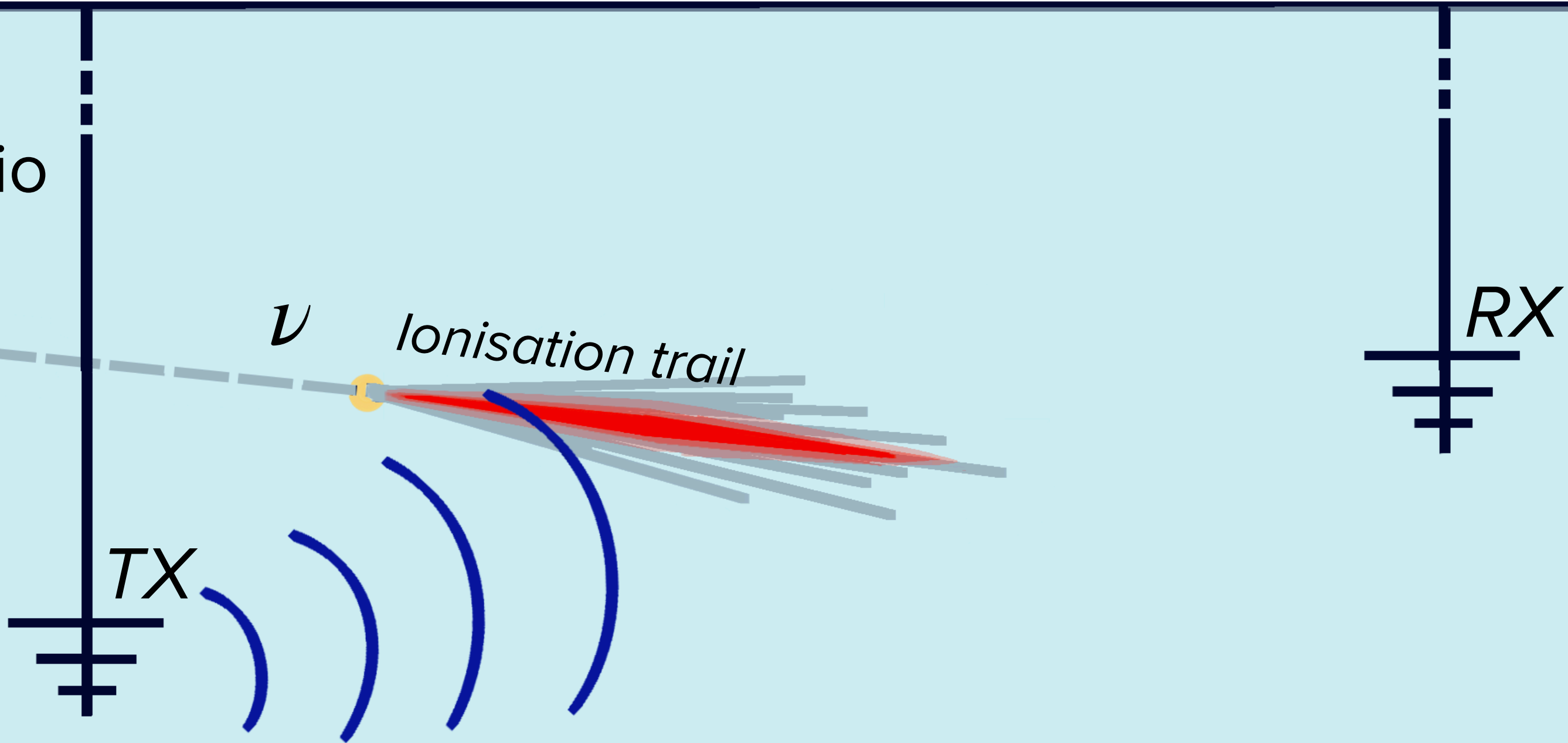
- ▶ The cascade's ionisation trail **reflects** incident radio waves



Radar detection of astrophysical particles

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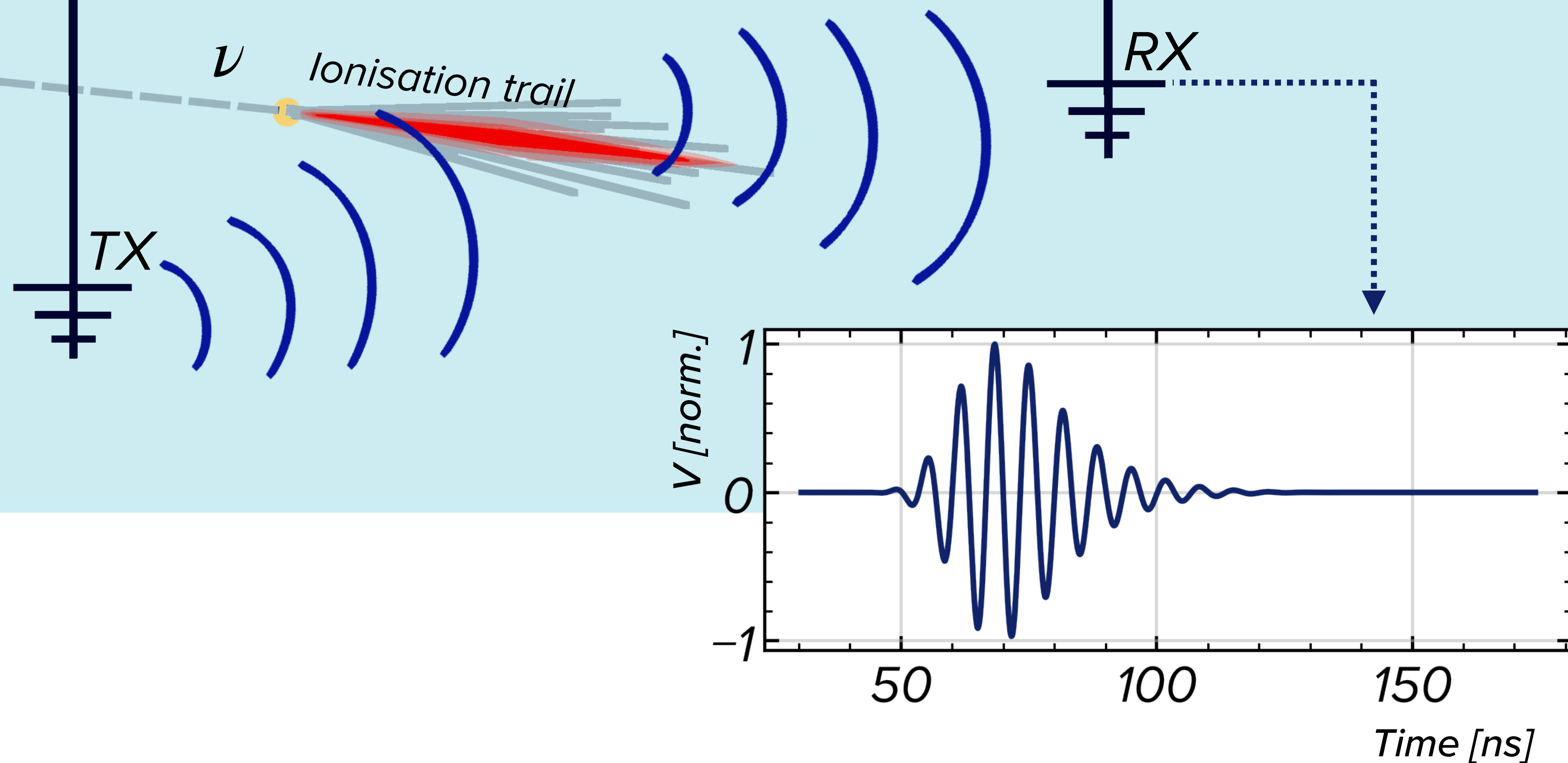
⇒ Detectable with a radar system



Radar detection of astrophysical particles

- ▶ The cascade's ionisation trail **reflects** incident radio waves

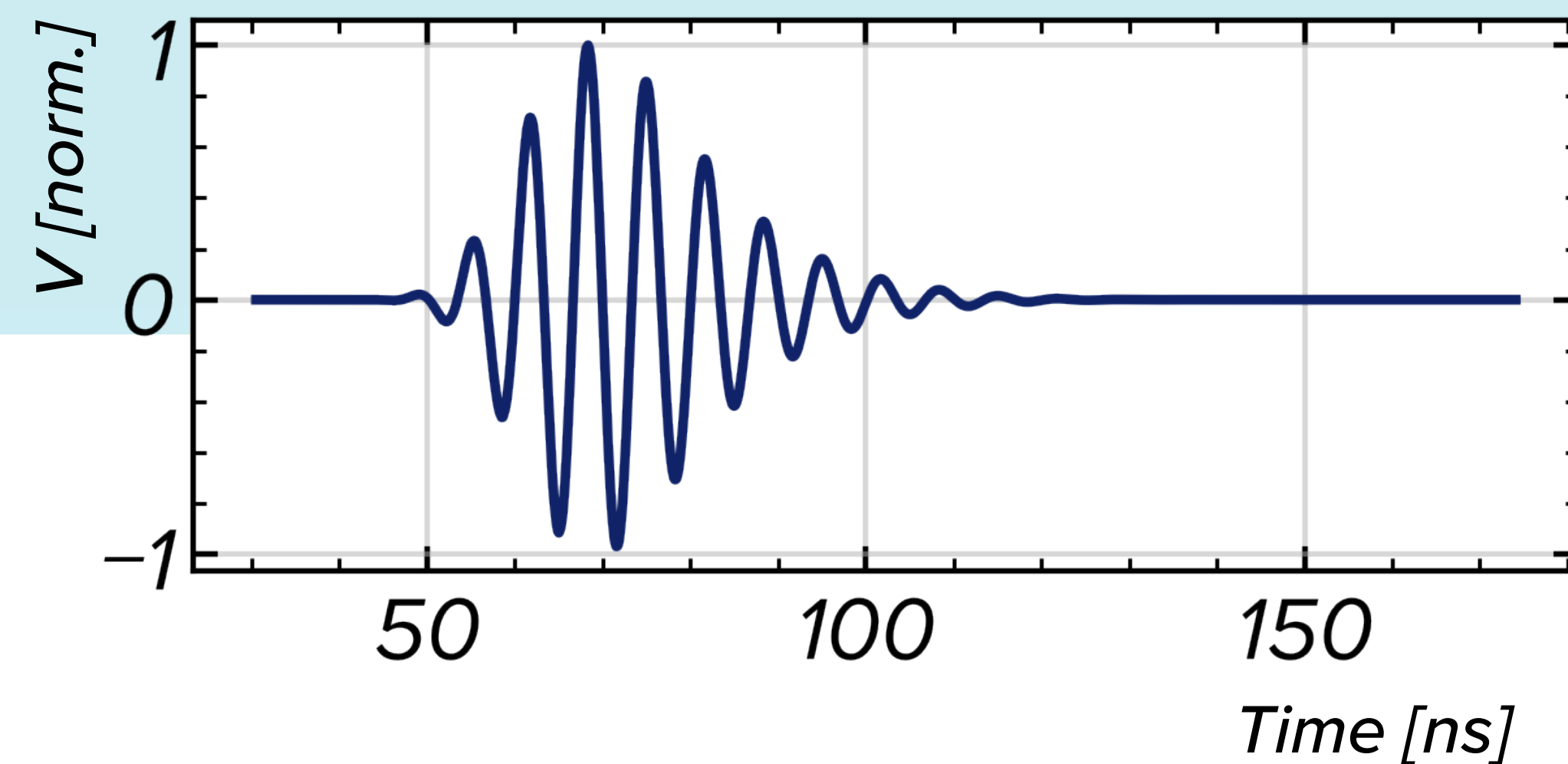
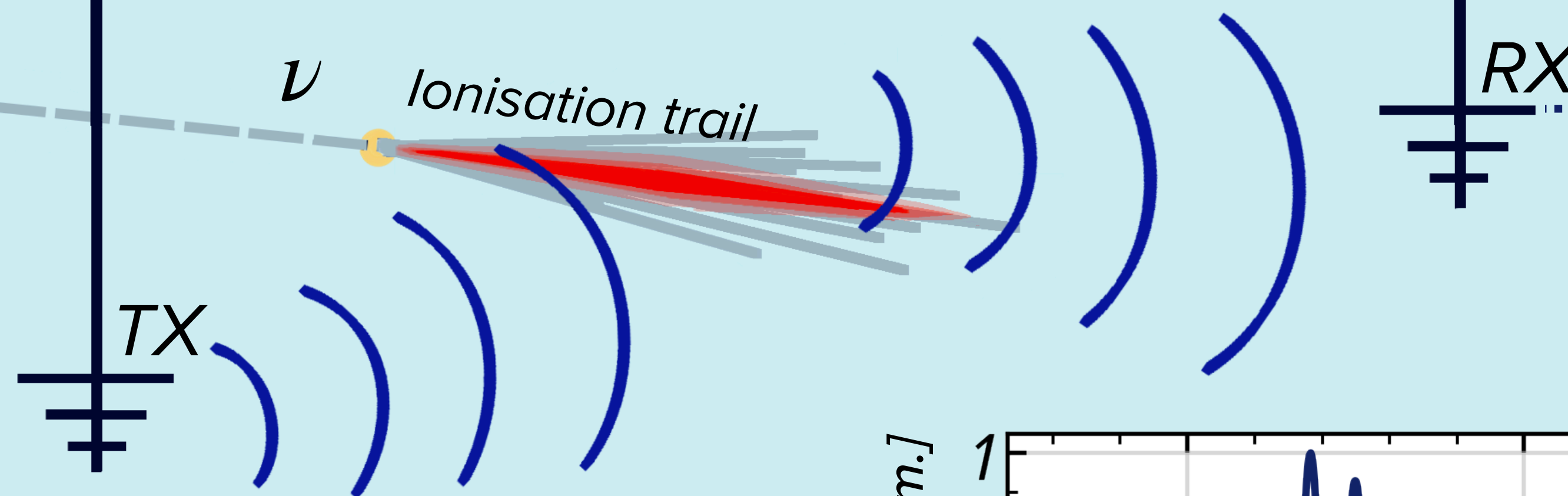
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Radar detection of astrophysical particles

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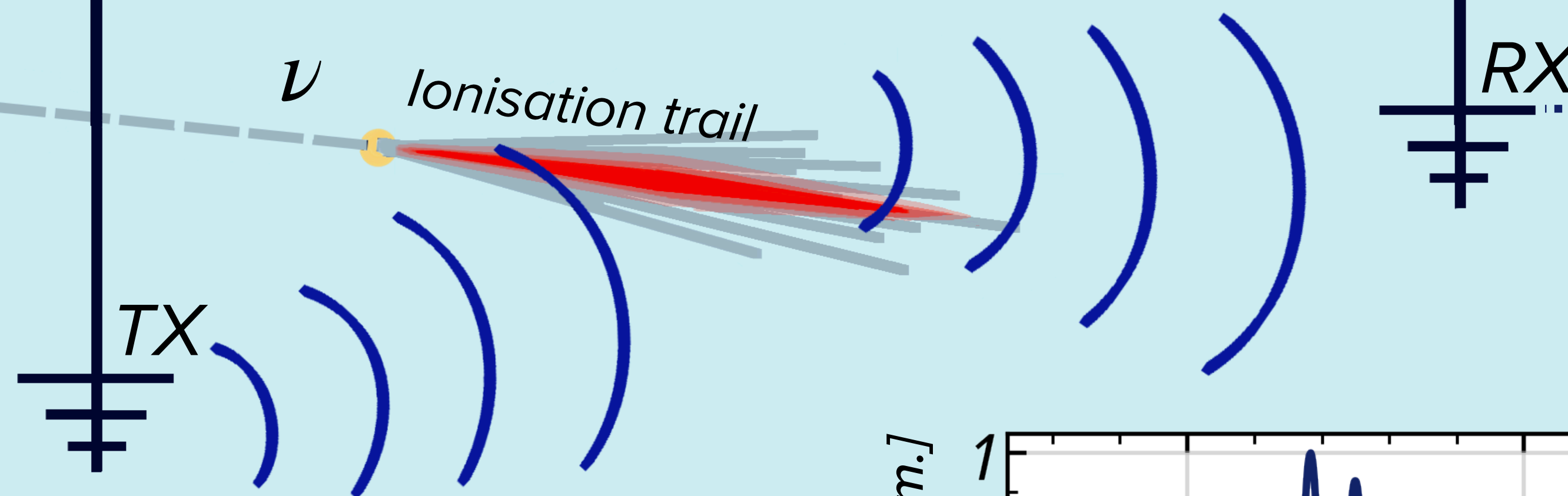


- ▶ Future **RET-N** UHE neutrino detector:
 - ▶ Large instrumented volume (radio)
 - ▶ Control over TX (⇒ RX) signal

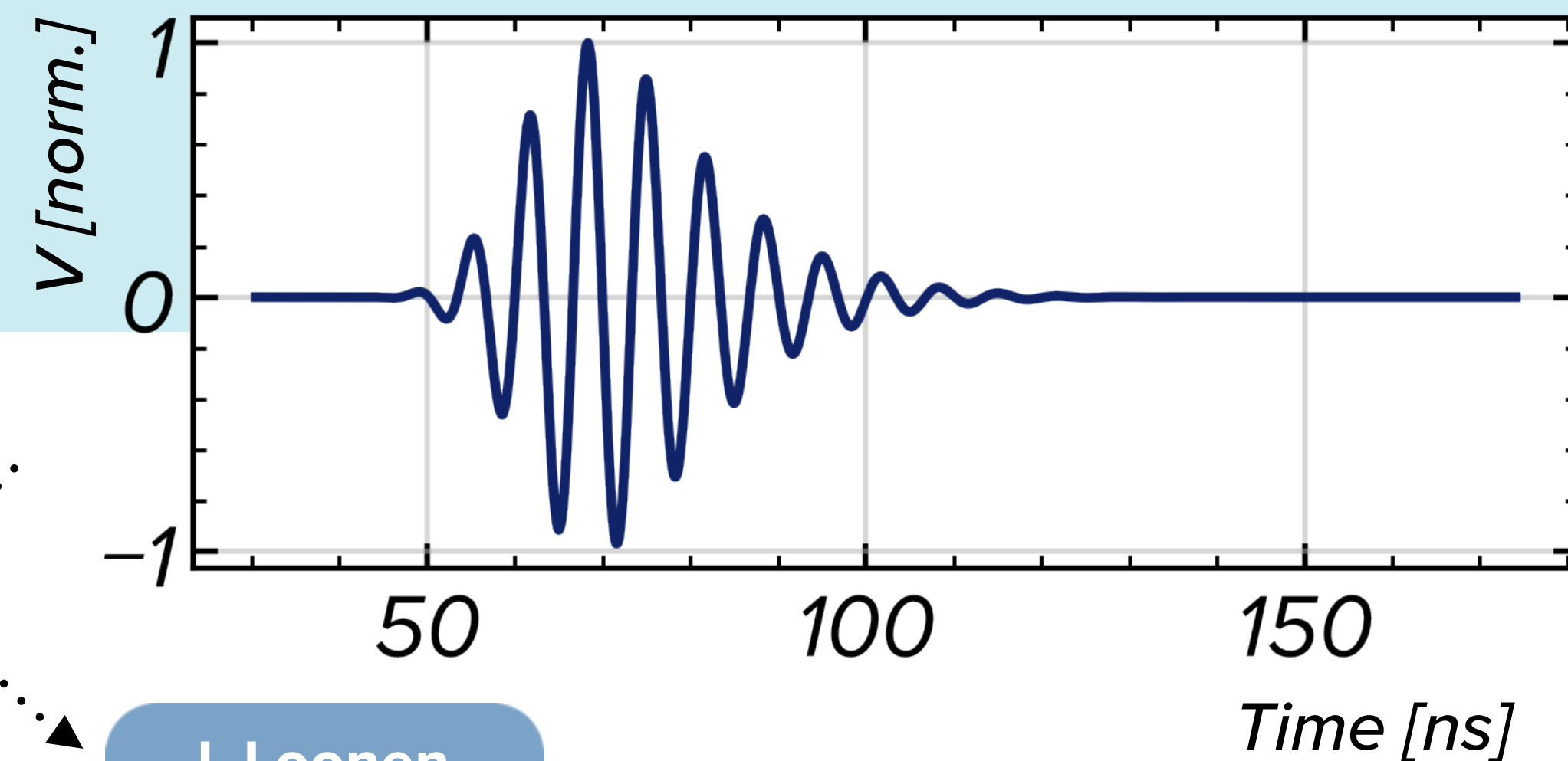
Radar detection of astrophysical particles

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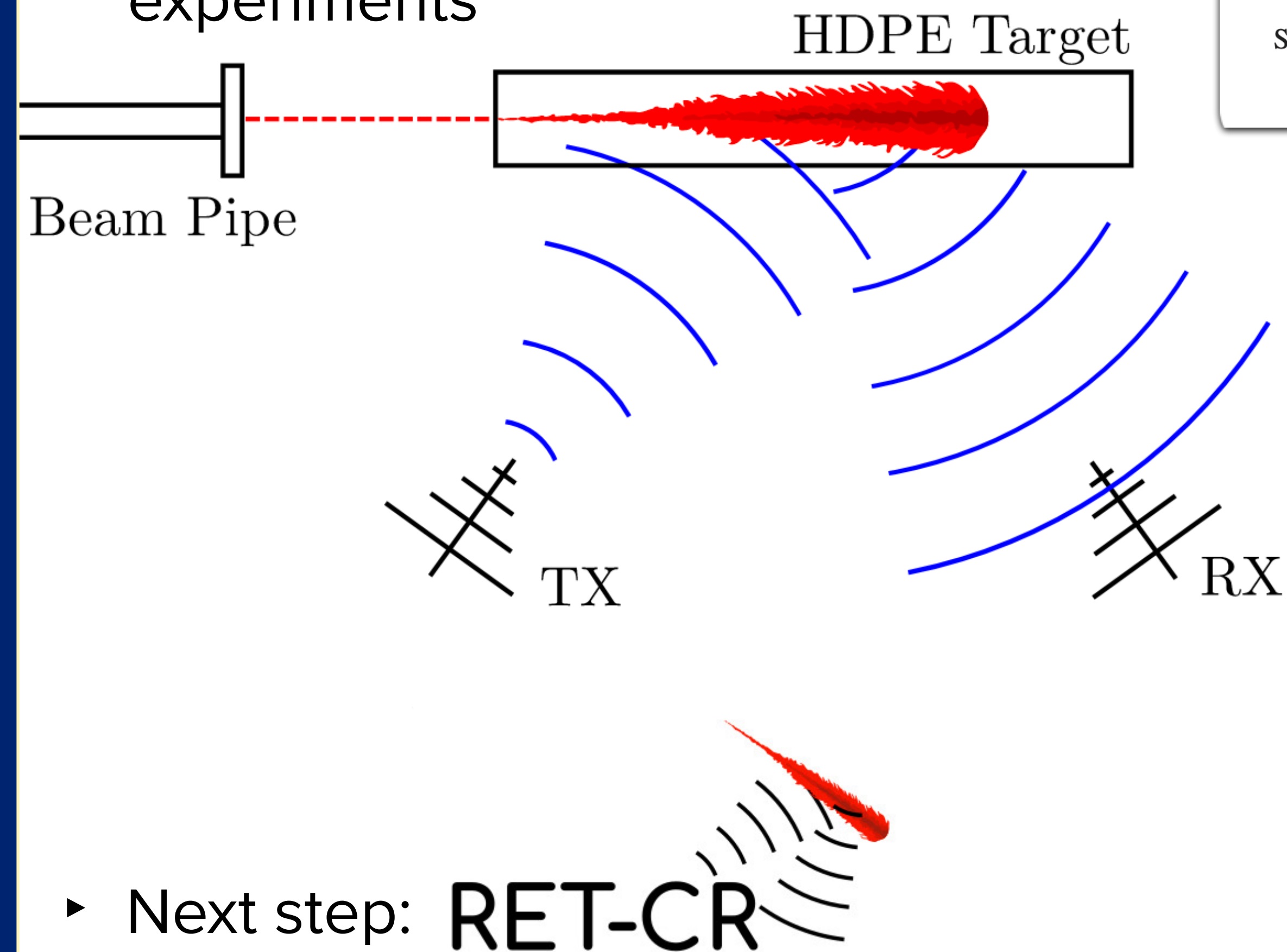
- ▶ Future **RET-N** UHE neutrino detector:
 - ▶ Large instrumented volume (radio)
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J. Loonen,
next talk!

Proof-of-concept

- Radar method has been demonstrated in SLAC laboratory experiments



- Next step: **RET-CR**

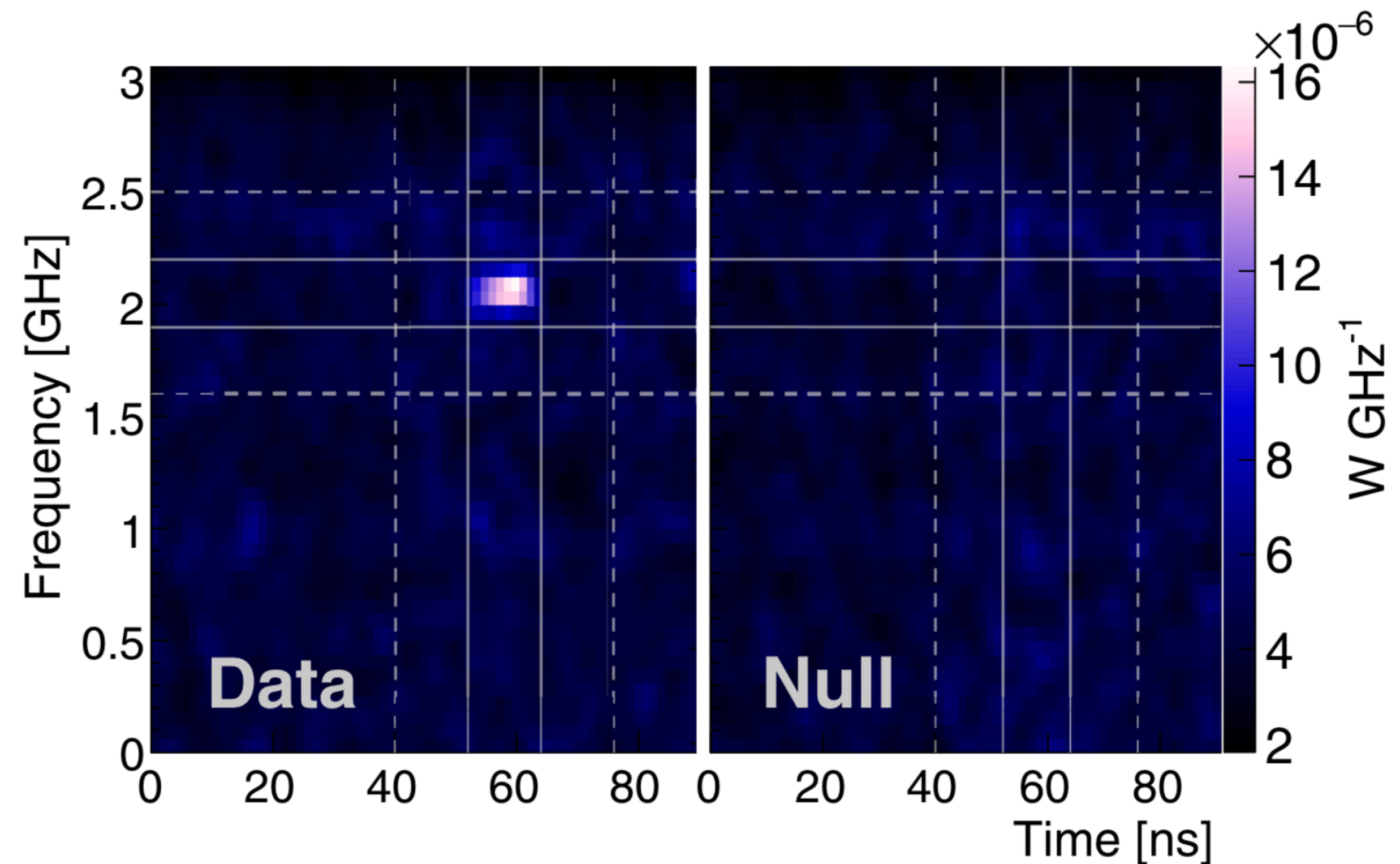
PHYSICAL REVIEW LETTERS **124**, 091101 (2020)

Editors' Suggestion

Featured in Physics

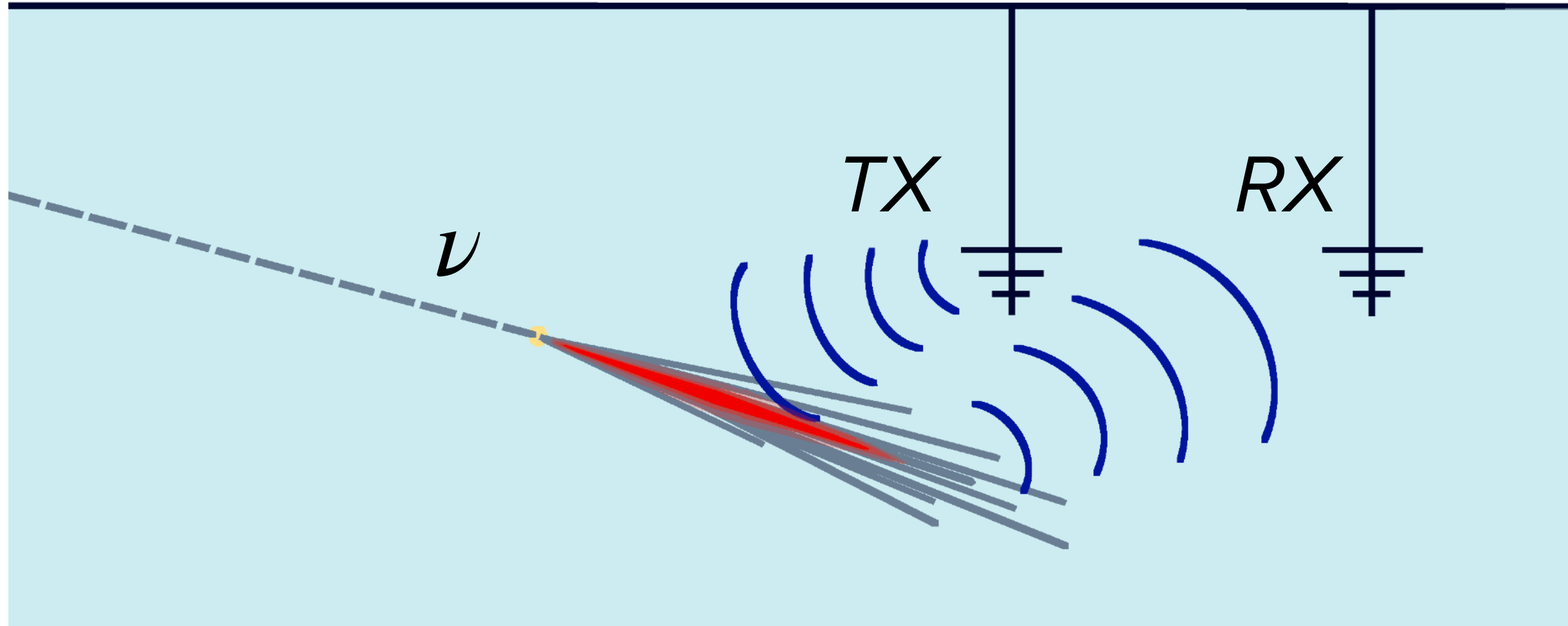
Observation of Radar Echoes from High-Energy Particle Cascades

S. Prohira^{1,*}, K. D. de Vries², P. Allison¹, J. Beatty¹, D. Besson^{3,4}, A. Connolly¹, N. van Eijndhoven²,
C. Hast⁵, C.-Y. Kuo⁶, U. A. Latif³, T. Meures⁷, J. Nam⁶, A. Nozdrina³, J. P. Ralston³,
Z. Riesen⁸, C. Sbrocco¹, J. Torres¹ and S. Wissel⁸

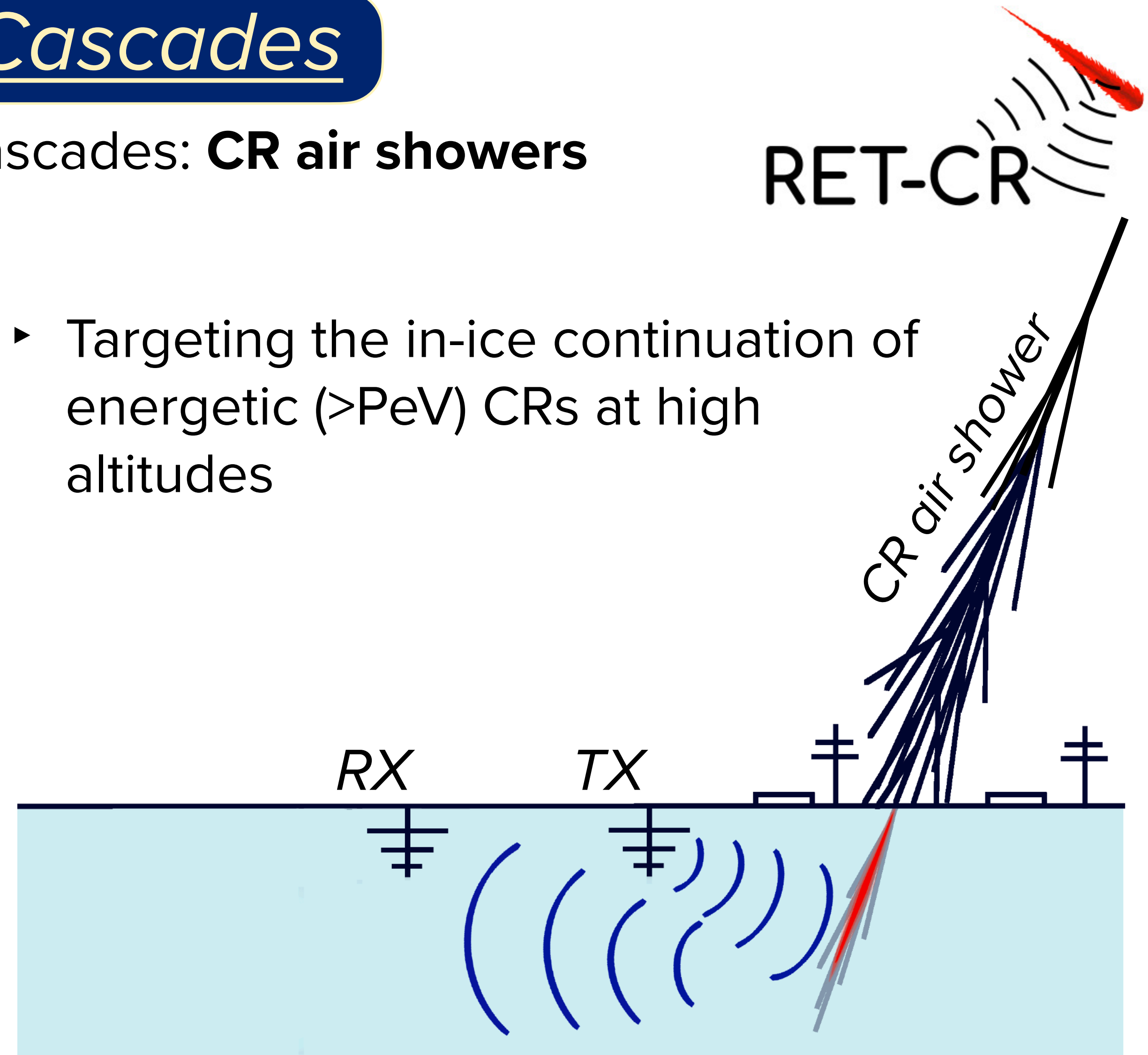


In-ice CR Cascades

- Demonstrate method in-nature with natural cascades: **CR air showers**



- Targeting the in-ice continuation of energetic ($> \text{PeV}$) CRs at high altitudes



- These secondary CR cascades closely resemble those produced by neutrinos

► *The successful detection of in-ice CR cascades will support targeting UHE neutrinos with the radar technique*

The RET-CR Experiment

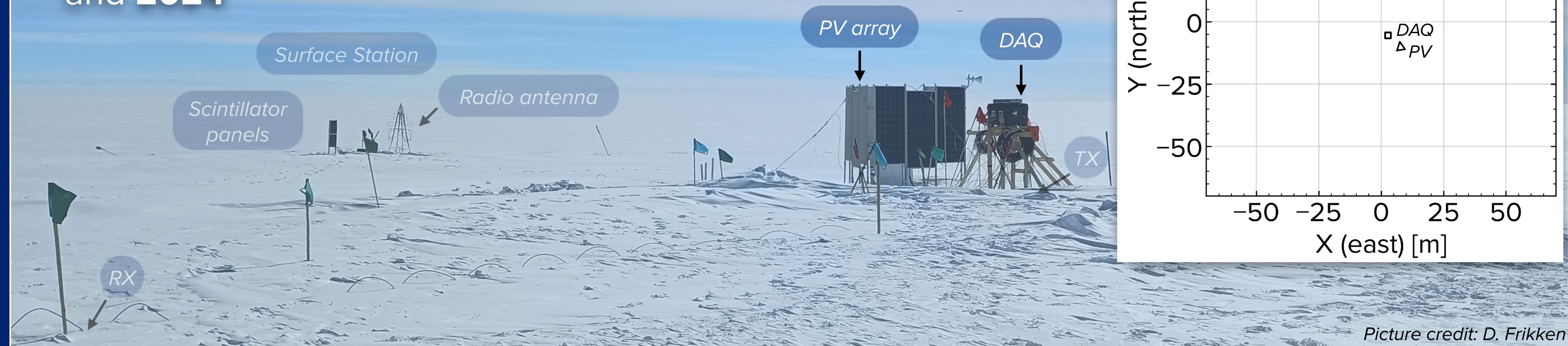
- Situated near **Summit Station, Greenland** in summers of **2023** and **2024**



Picture credit: D. Frikken

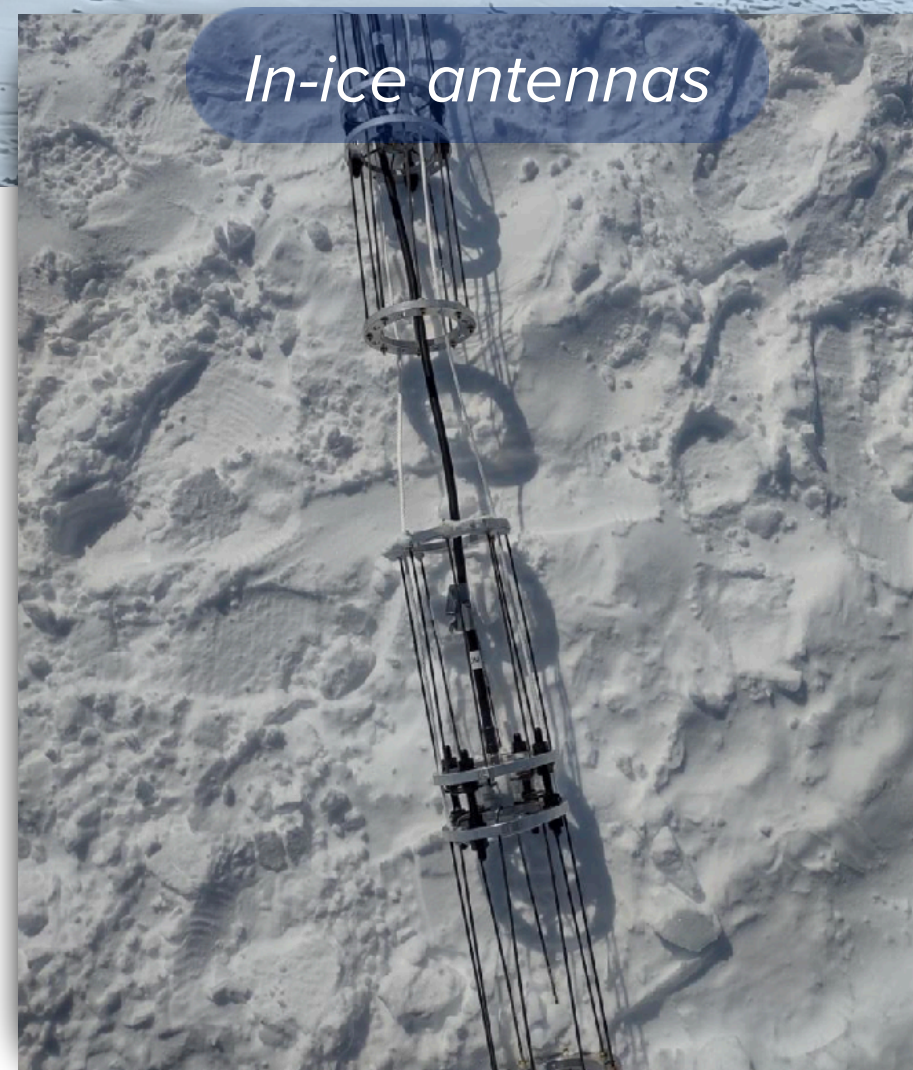
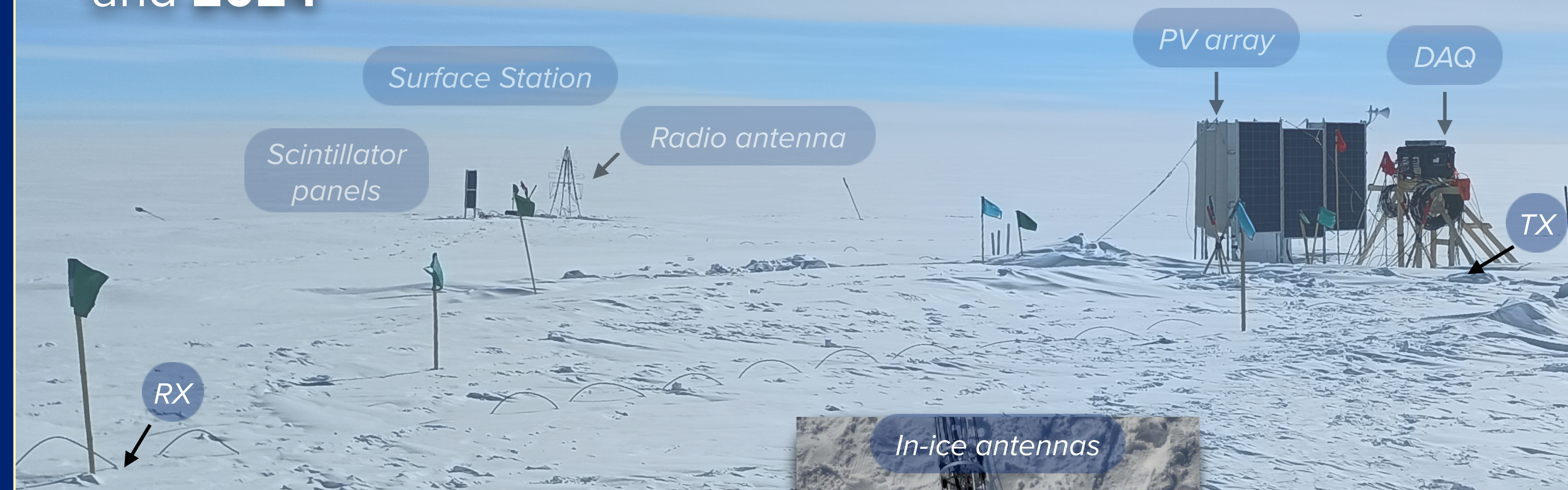
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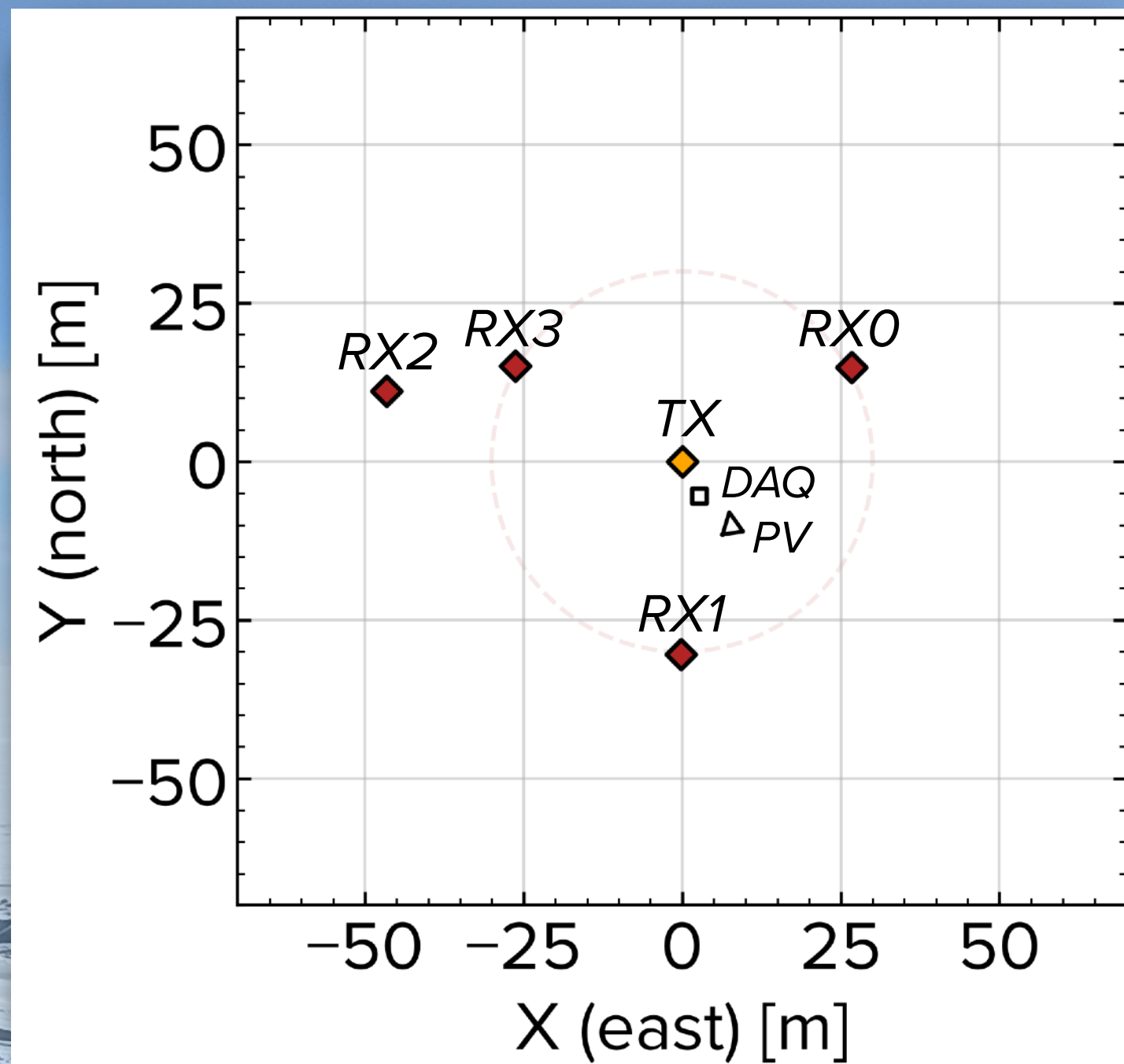


The RET-CR Experiment

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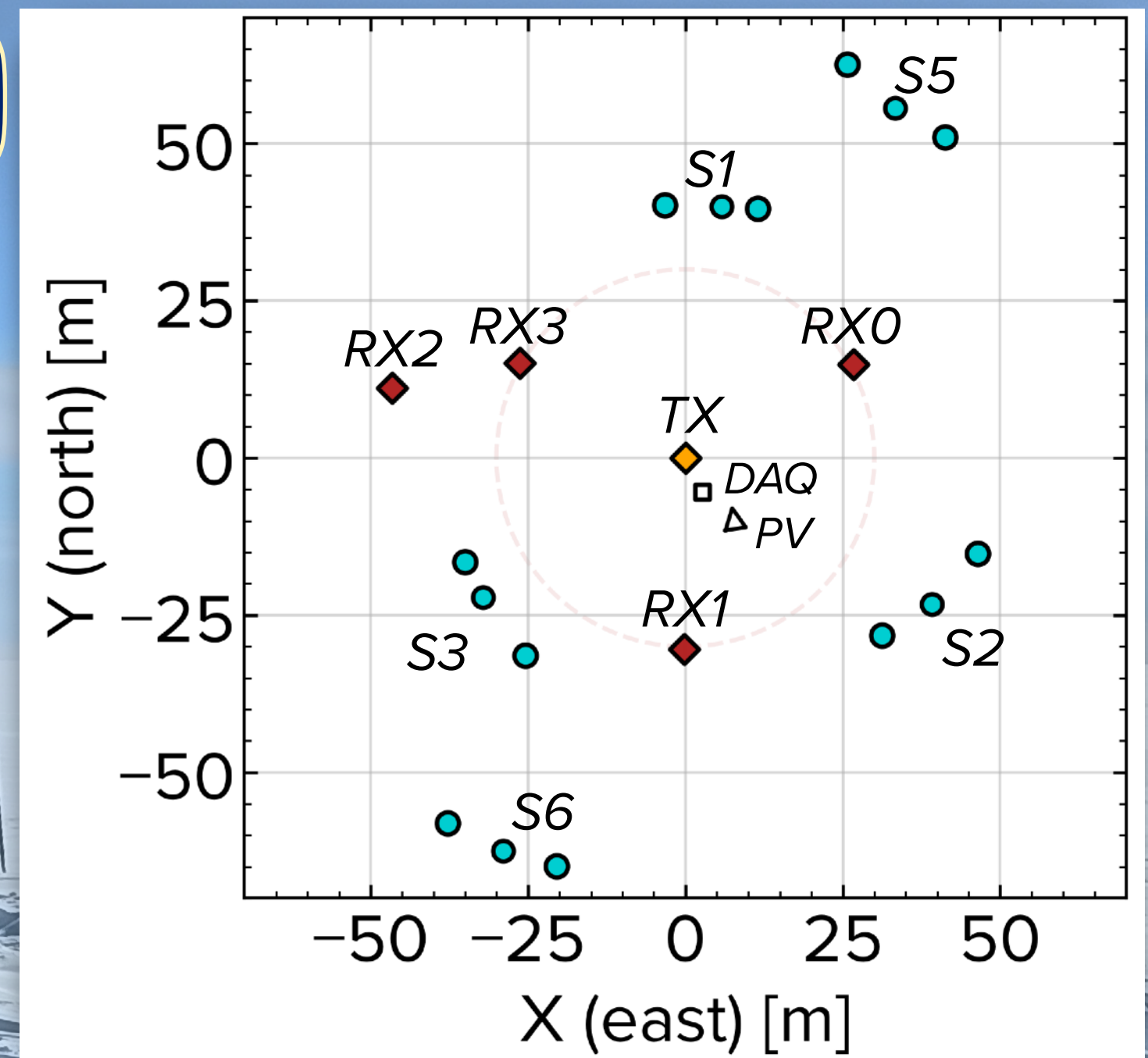
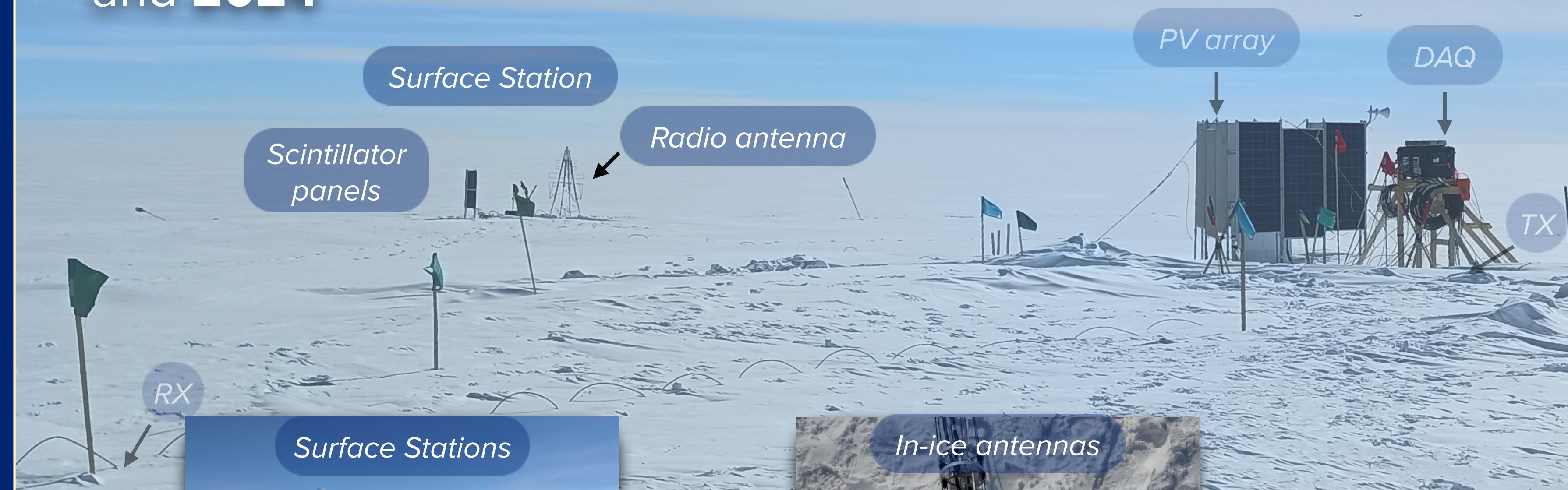
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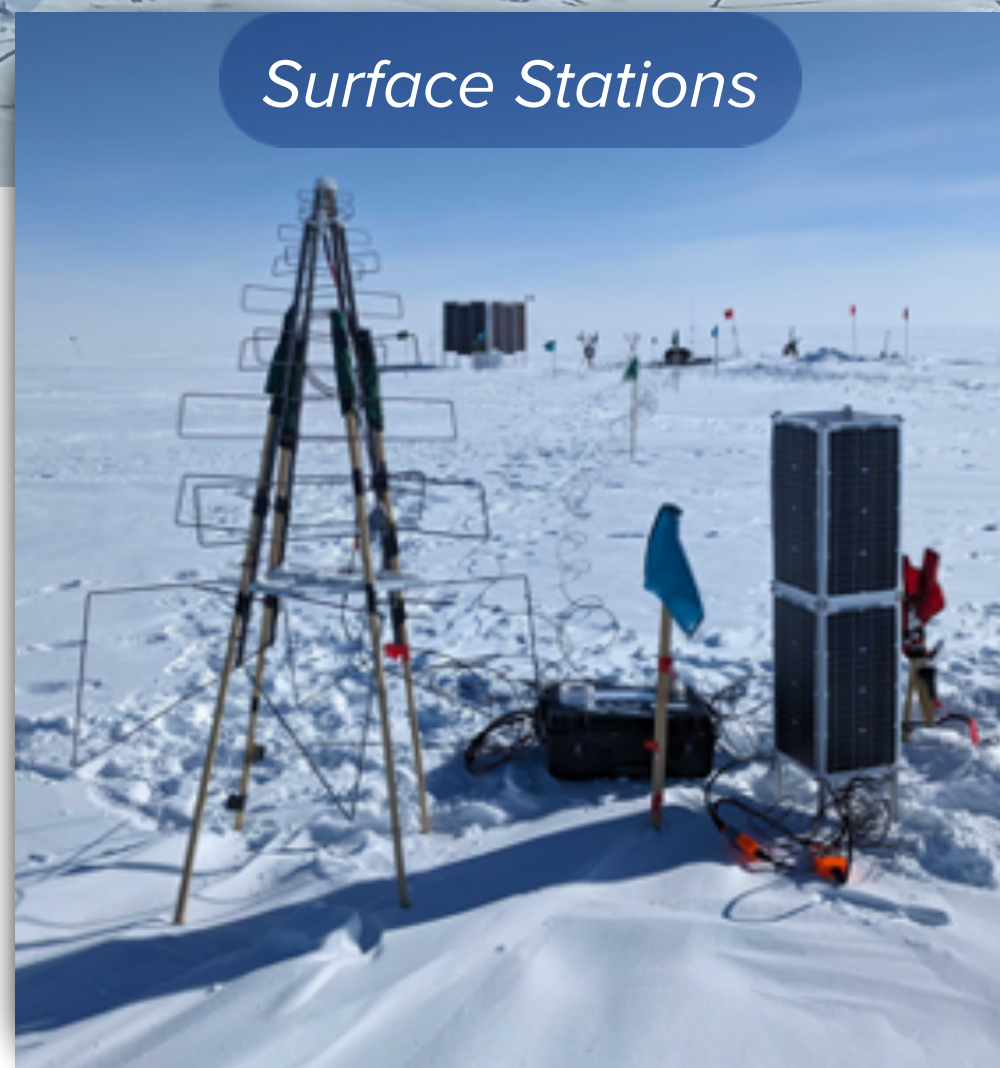
Picture credit: D. Frikken

The RET-CR Experiment

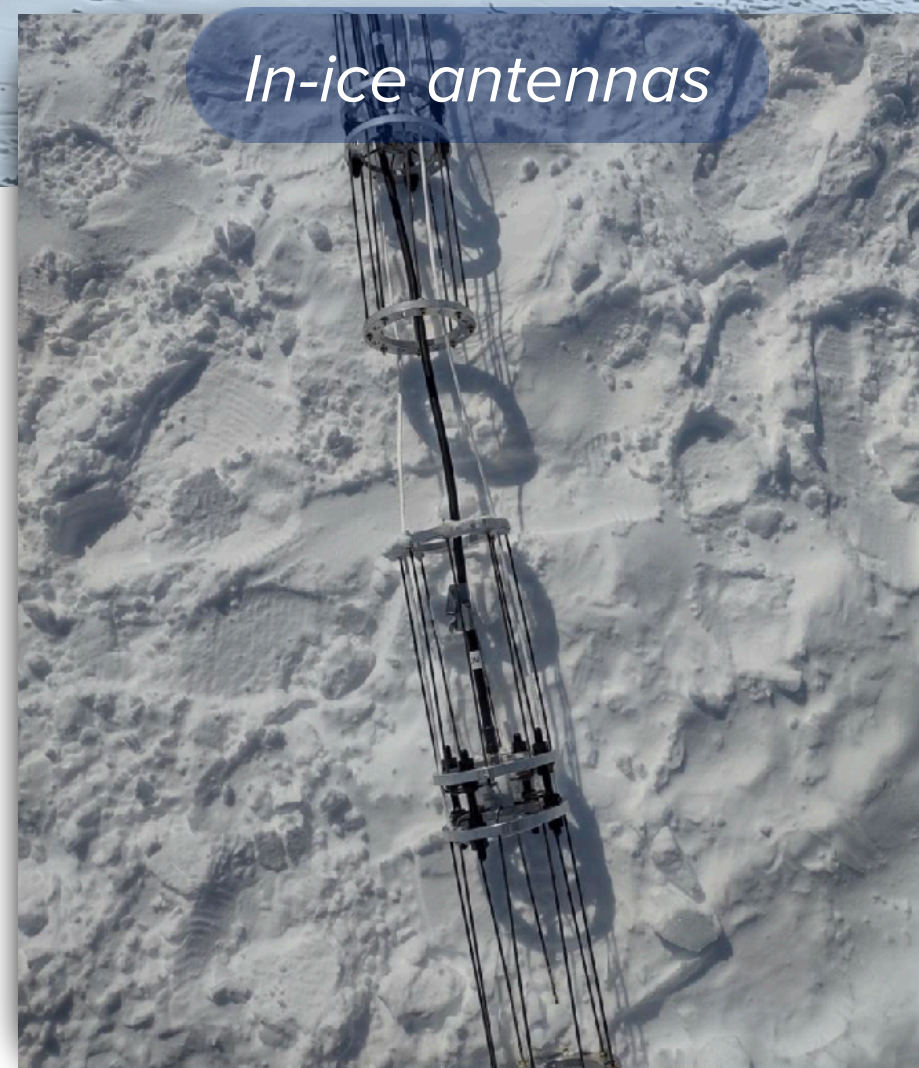
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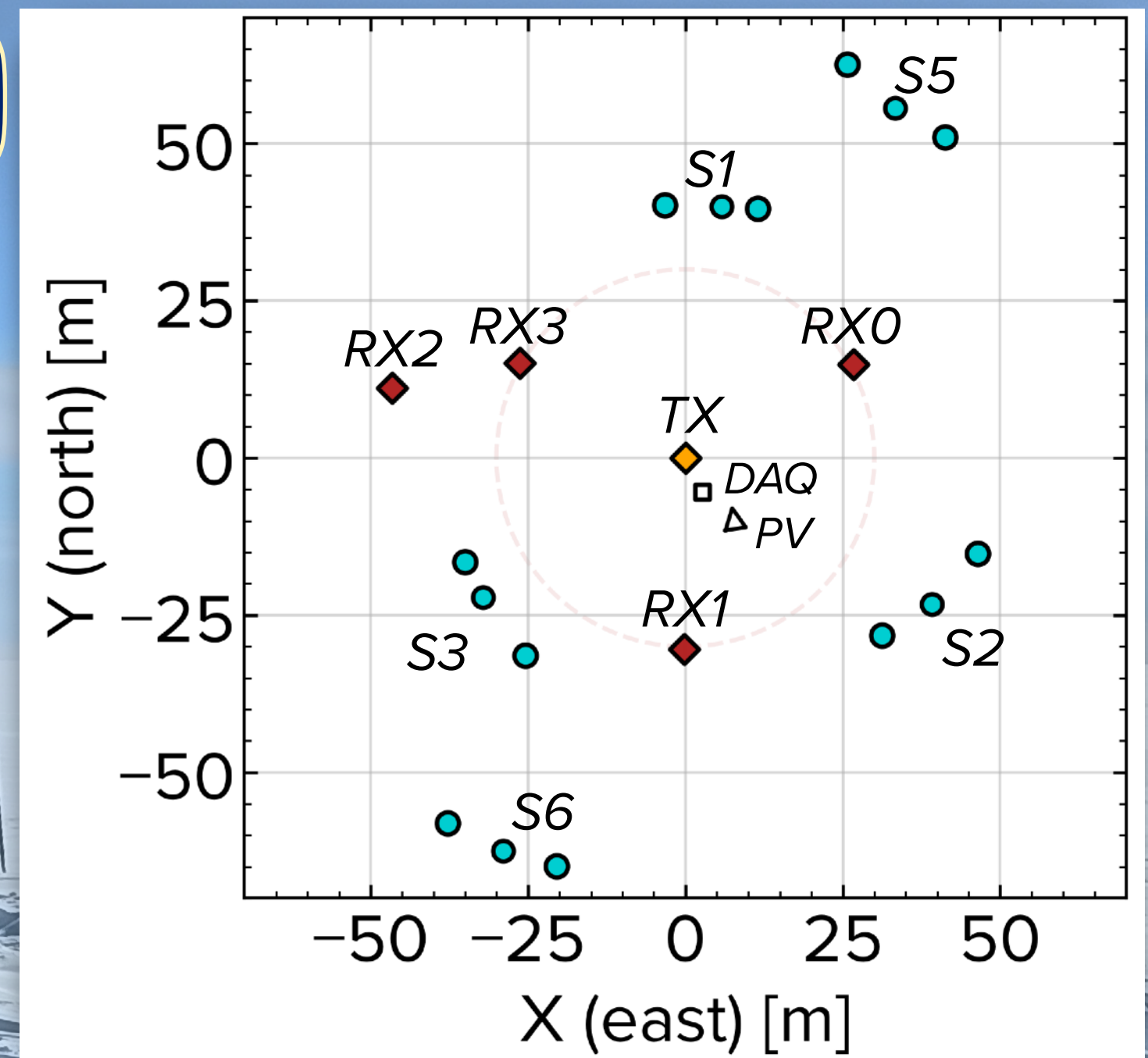
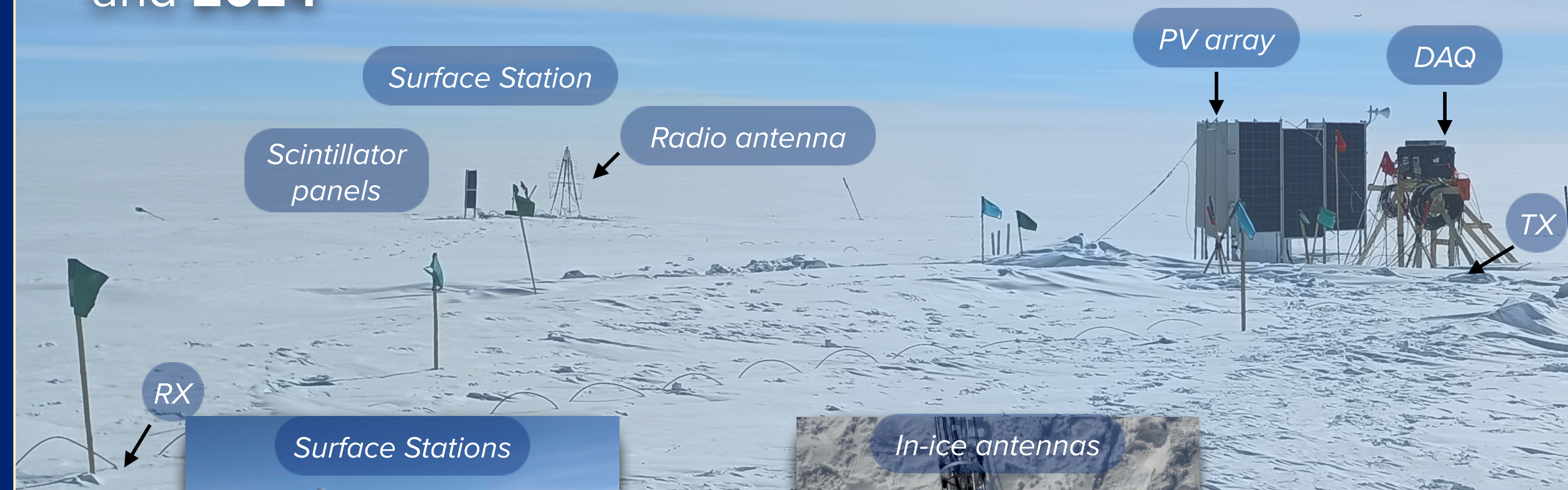
Picture credit: S. De Kockere



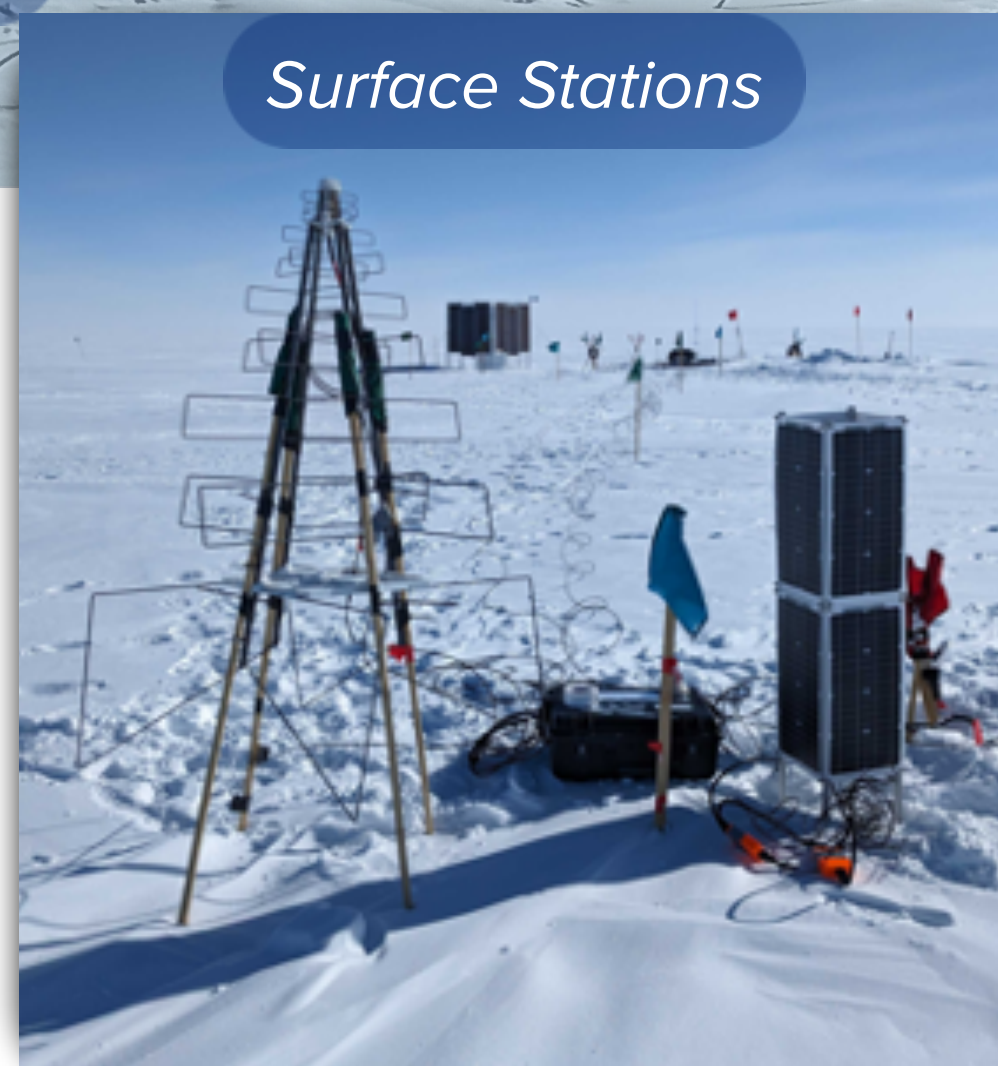
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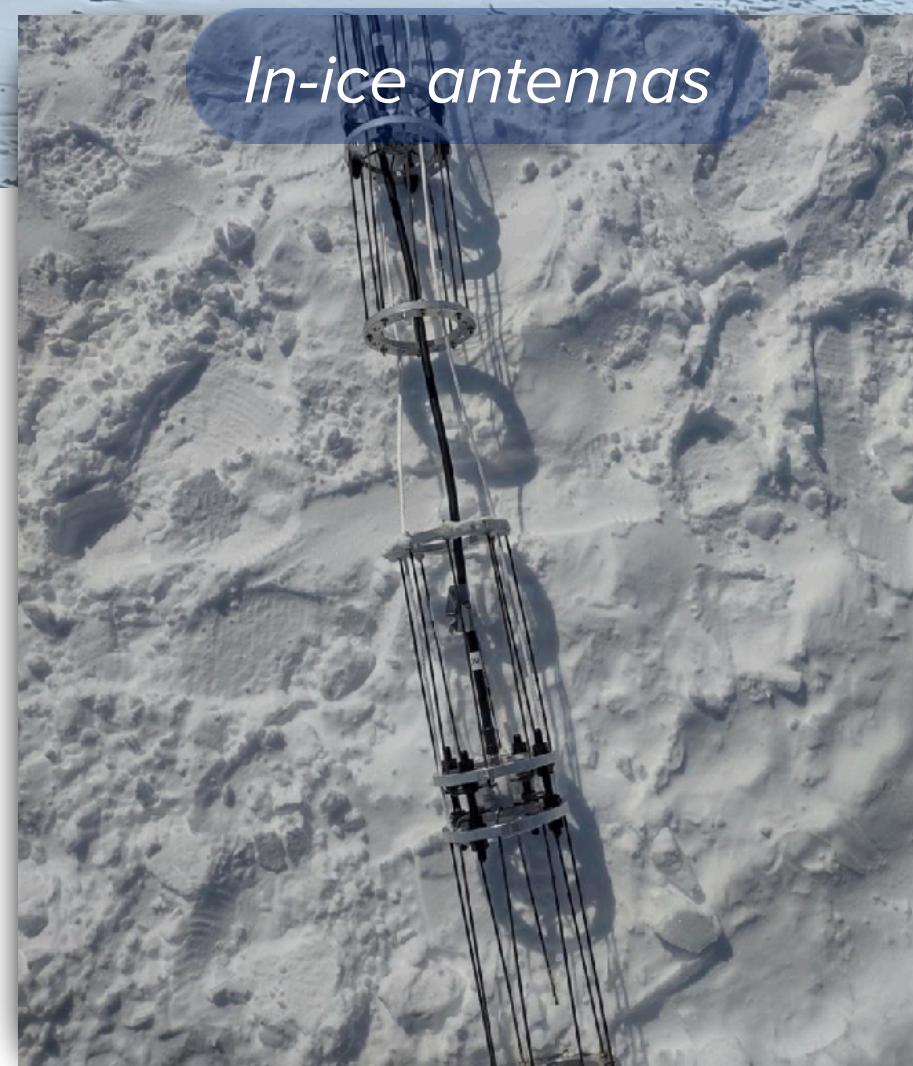


Picture credit: D. Frikken



Picture credit: S. De Kockere

→
Act as
triggers
for



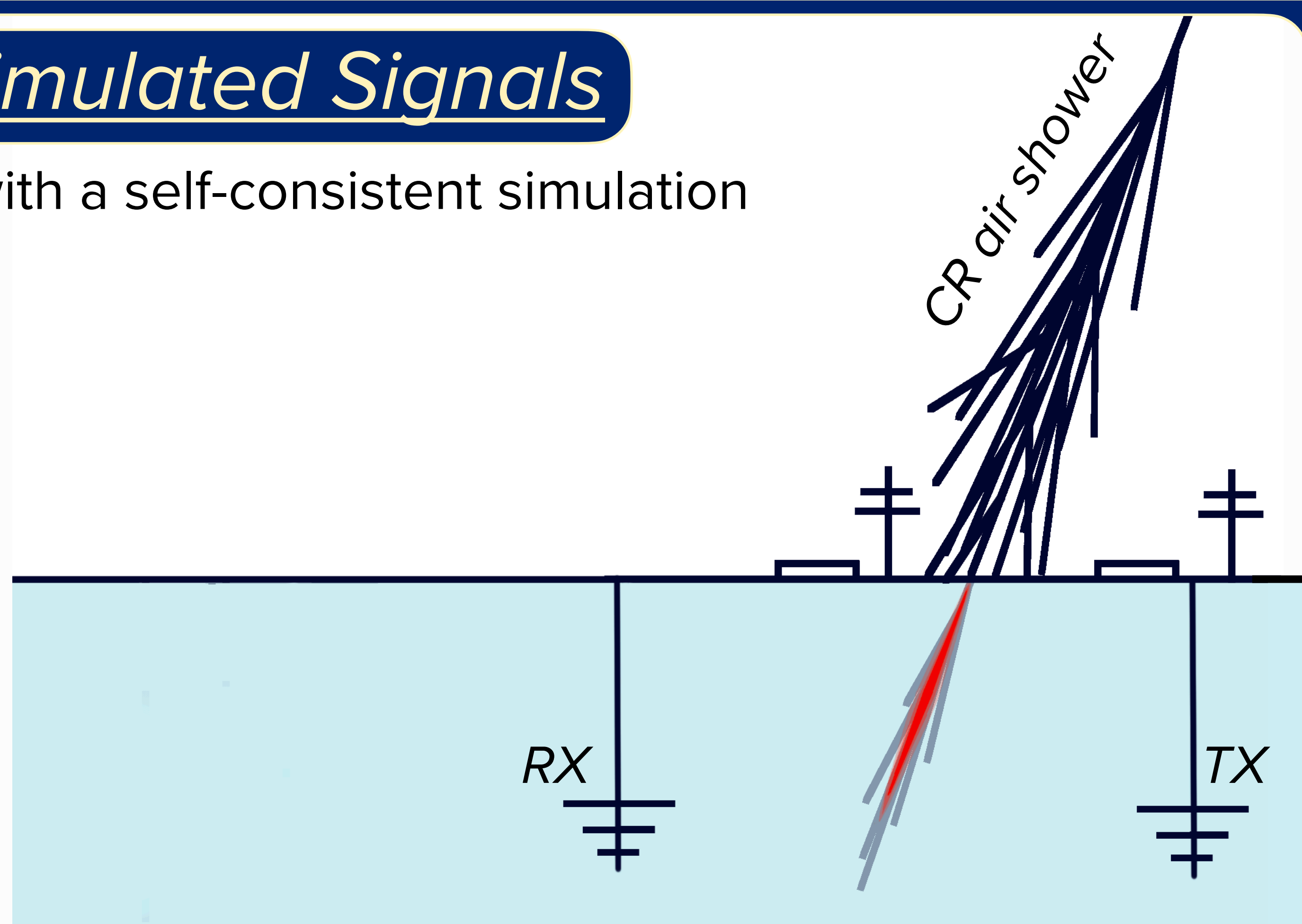
Picture credit: D. Frikken

- Use surface station detections to trigger and validate findings of the radar system
- Perform signal propagation studies of the near surface ice

RET-CR Simulated Signals

- Exploring the combined RET-CR signal with a self-consistent simulation framework →

*K. Nivedita et al., 2026
(arXiv:2607.24955)*



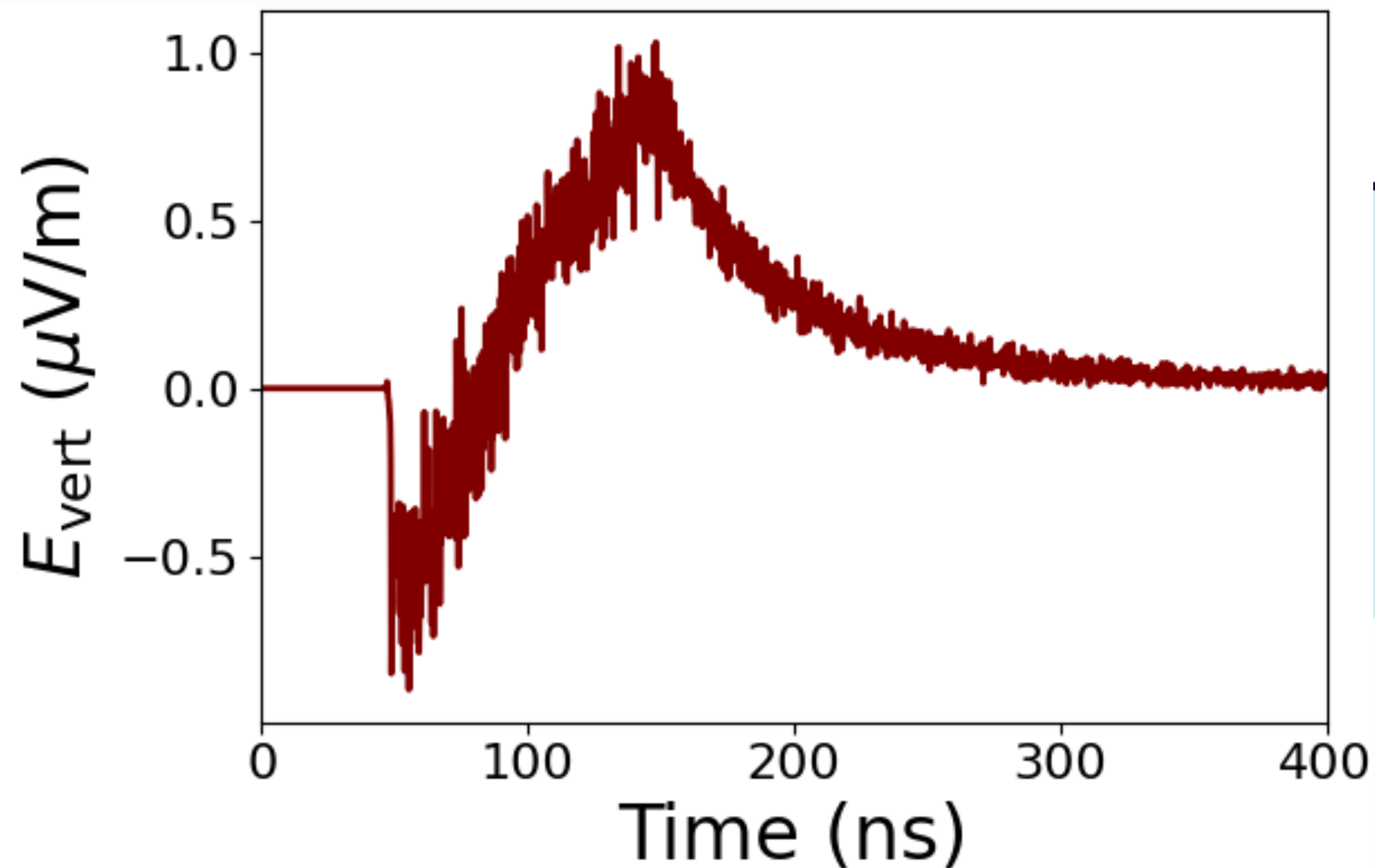
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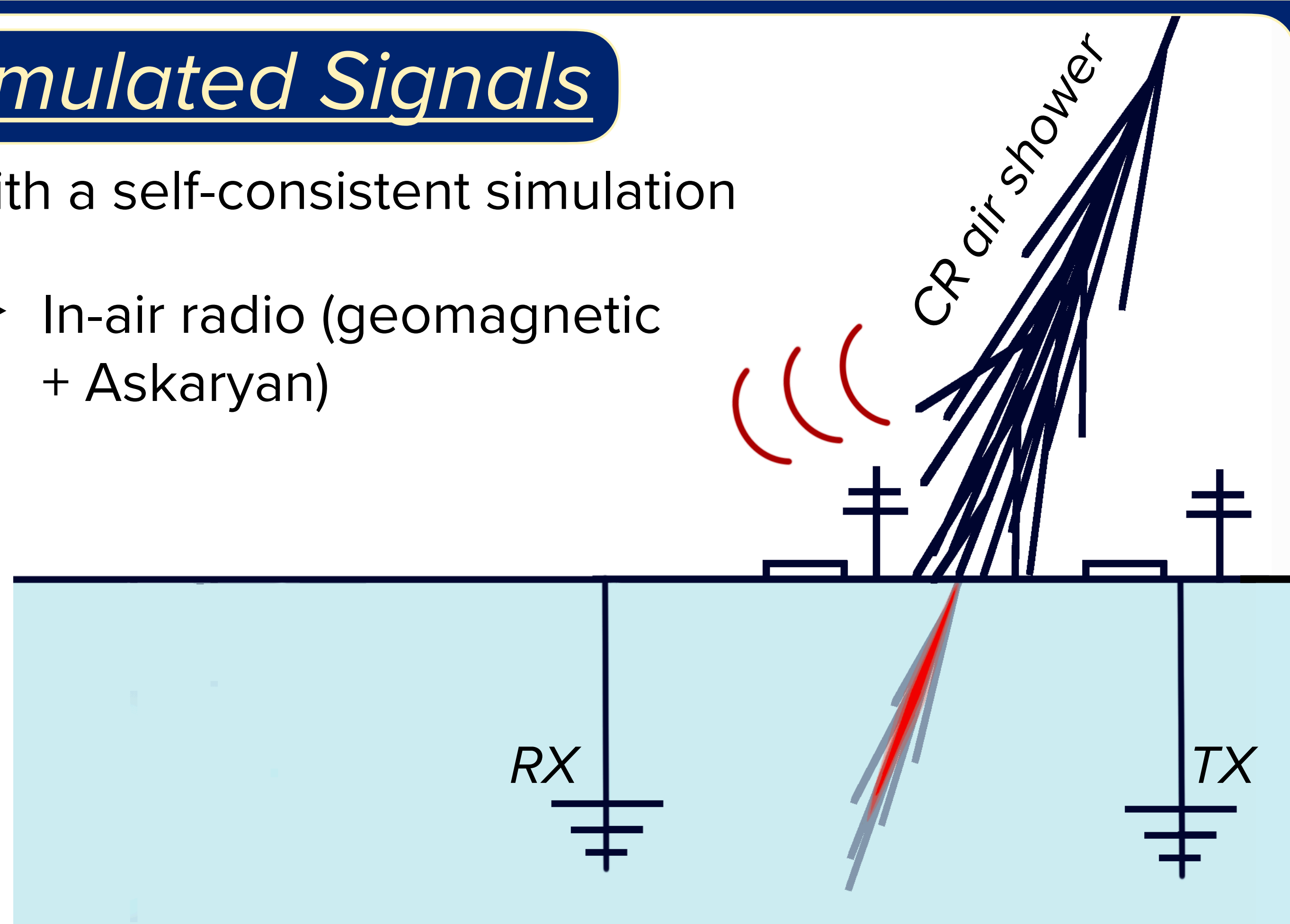
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- ▶ In-air radio (geomagnetic + Askaryan)

Credit: K. Nivedita



— In-air CR radio (x0.1)

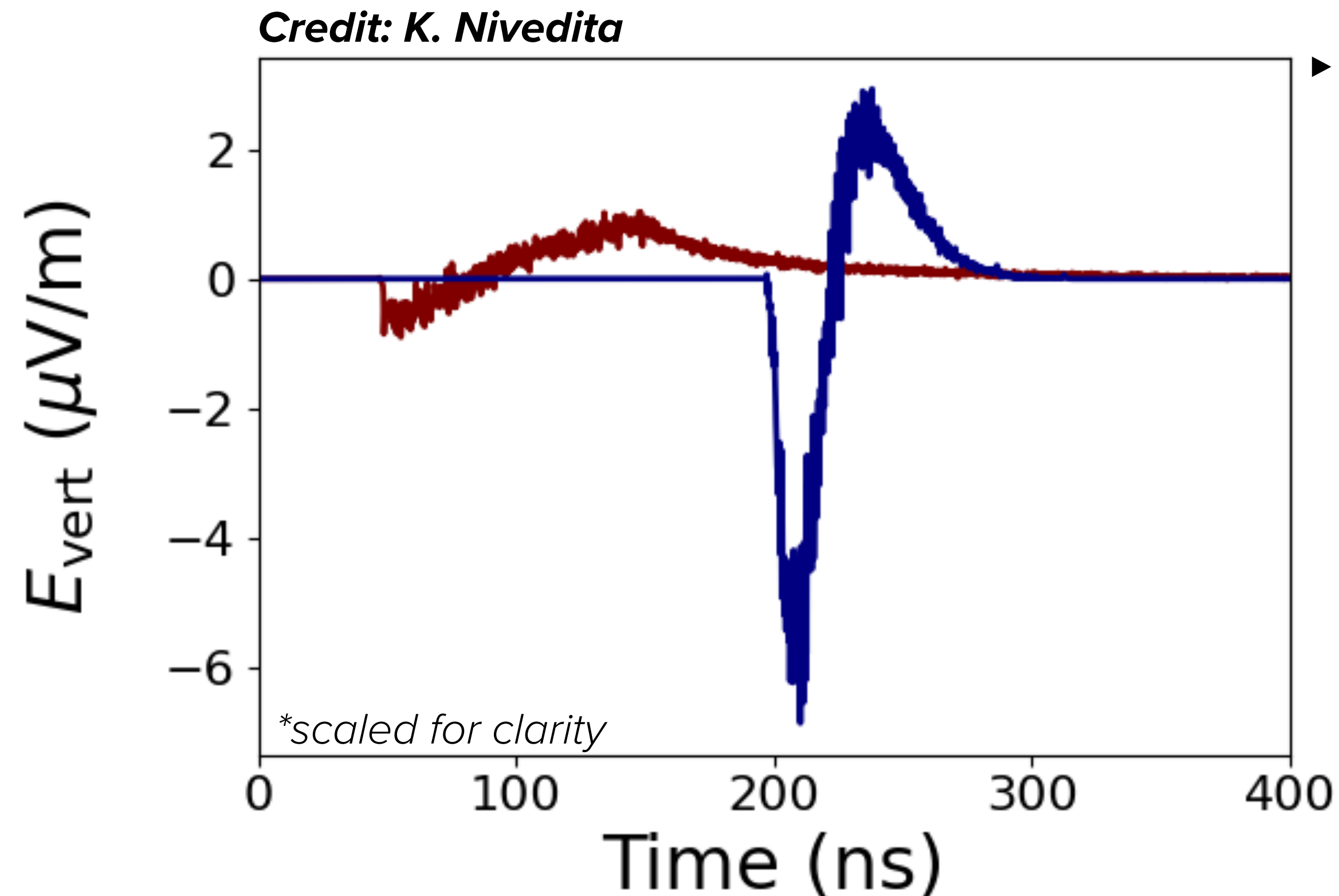


RET-CR Simulated Signals

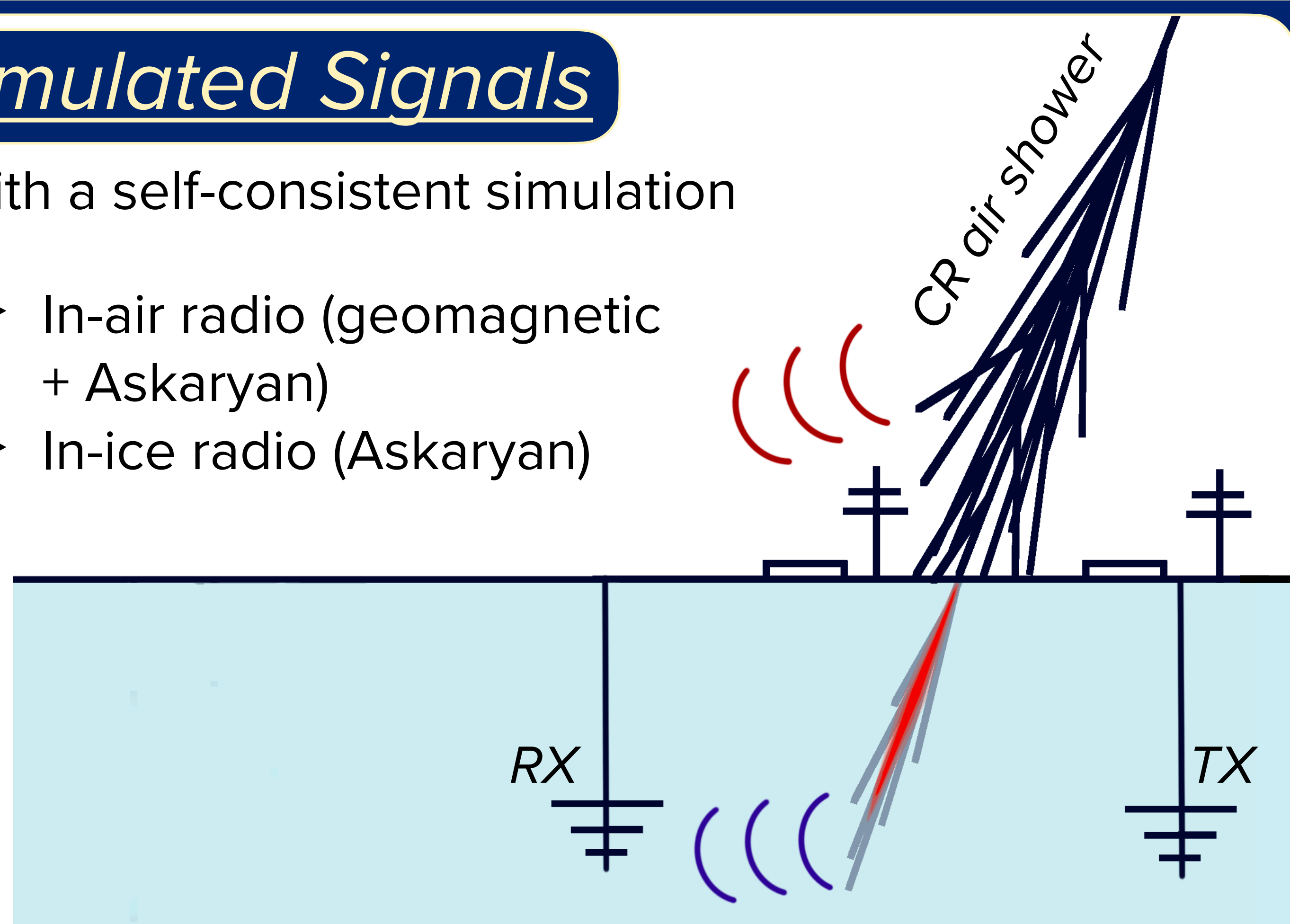
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- ▶ In-air radio (geomagnetic + Askaryan)
- ▶ In-ice radio (Askaryan)



— In-air CR radio (x0.1)
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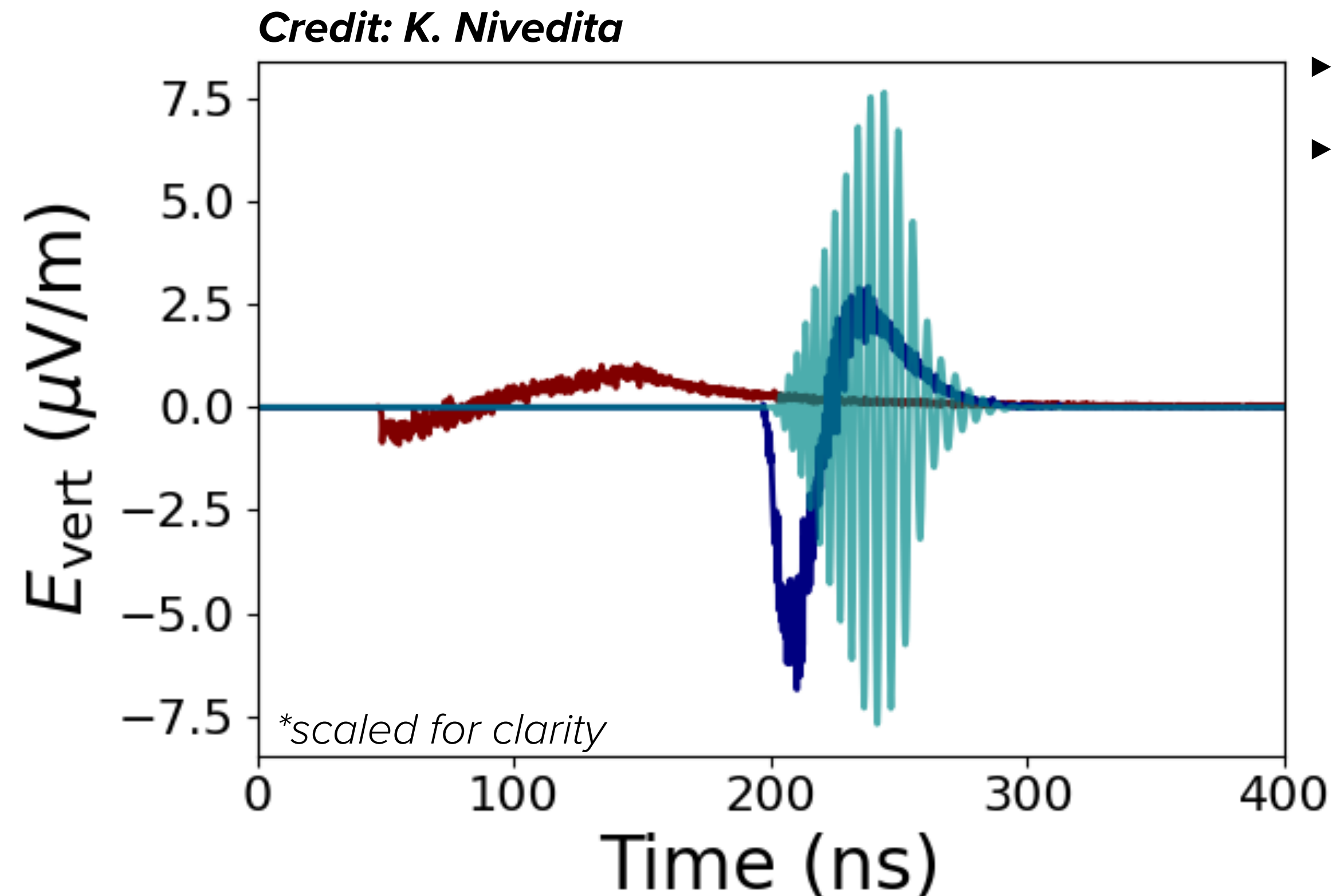


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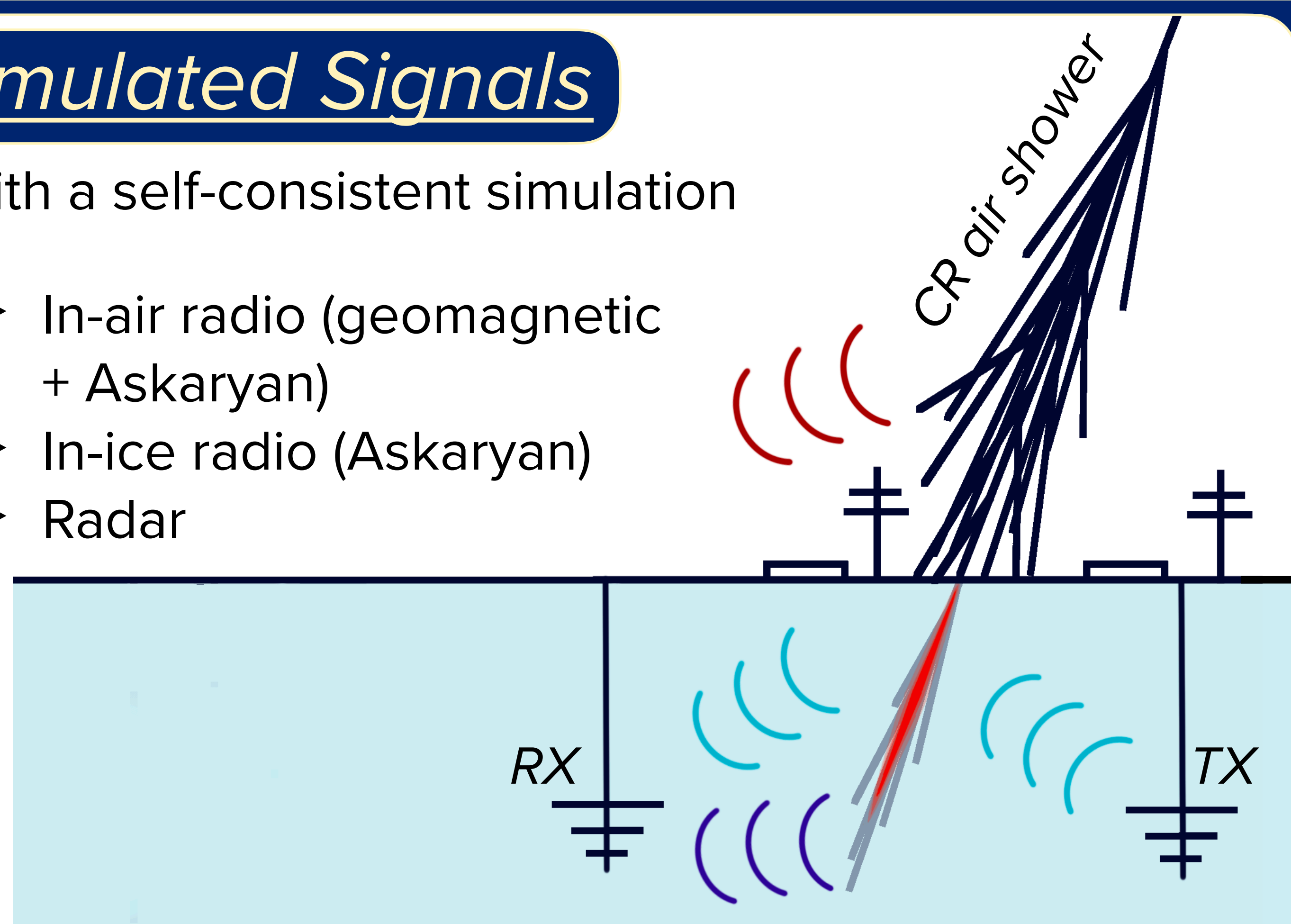
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- ▶ In-air radio (geomagnetic + Askaryan)
- ▶ In-ice radio (Askaryan)
- ▶ Radar

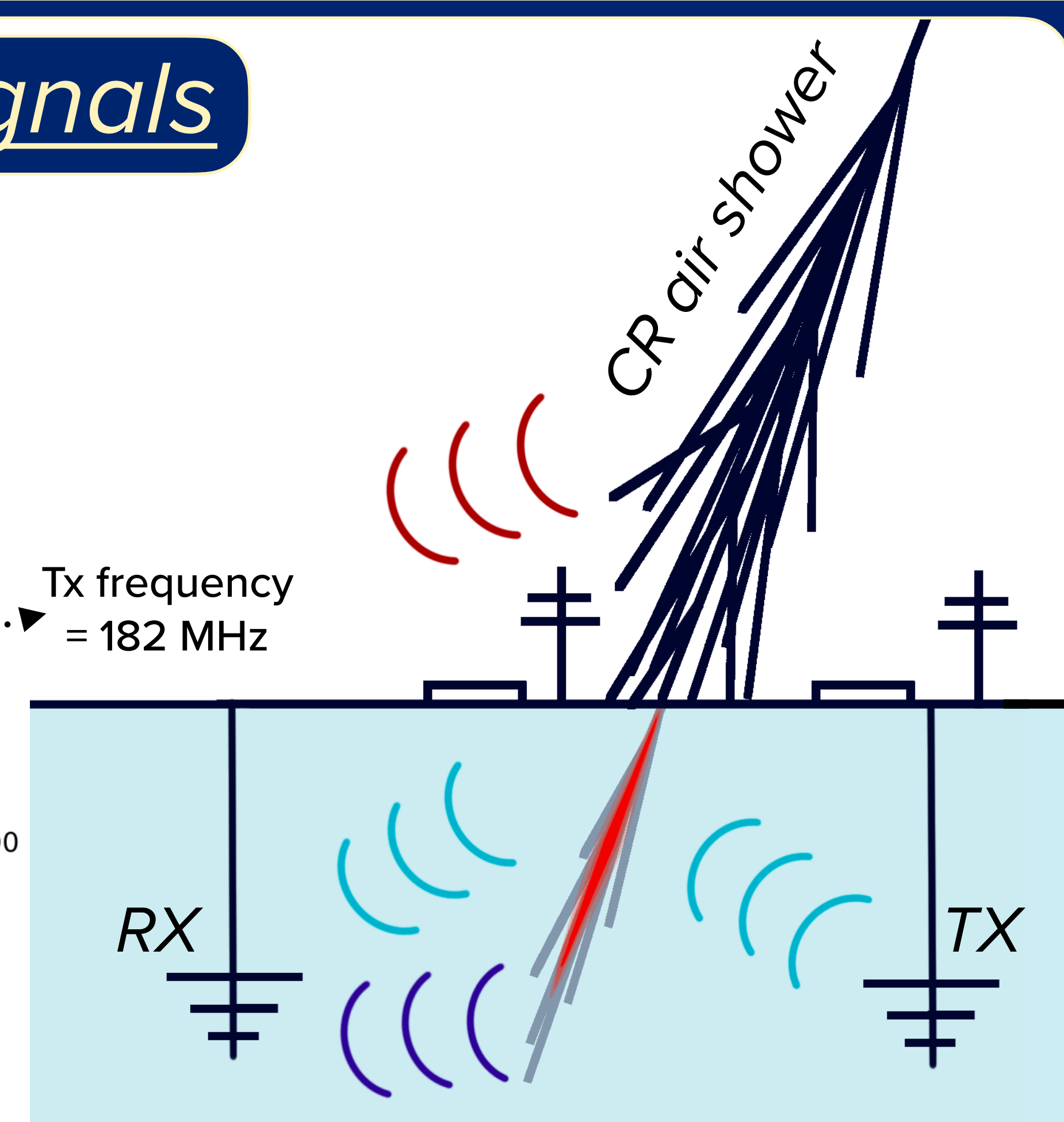
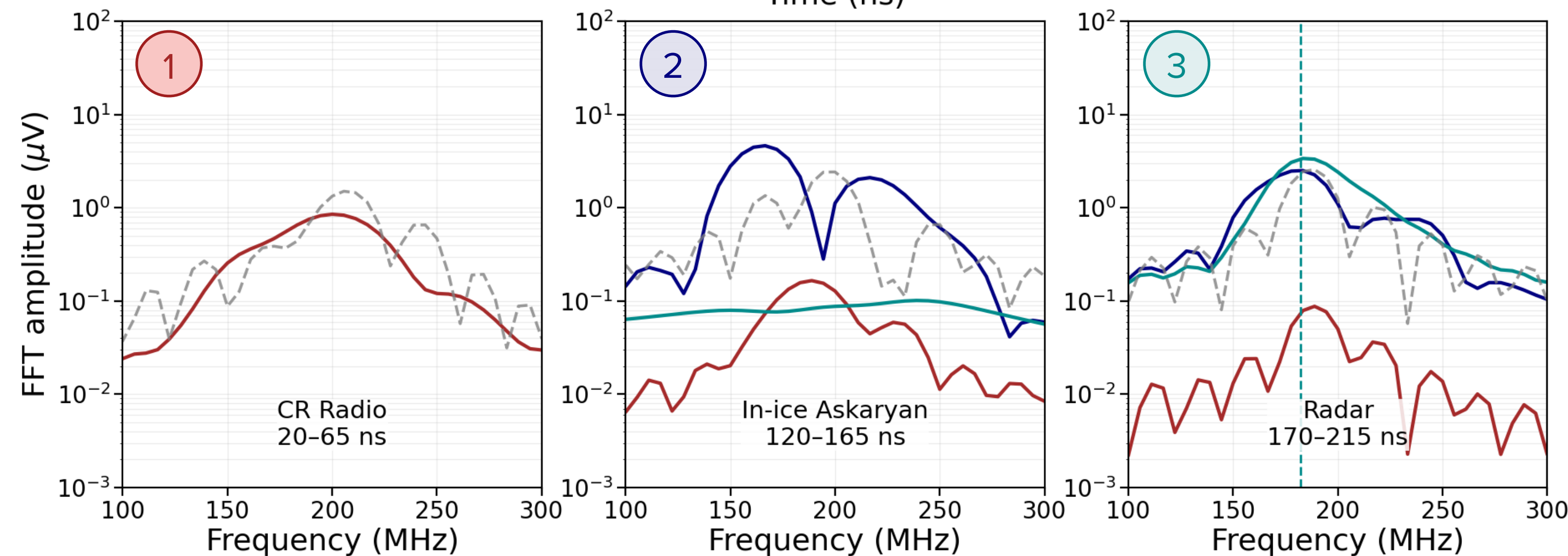
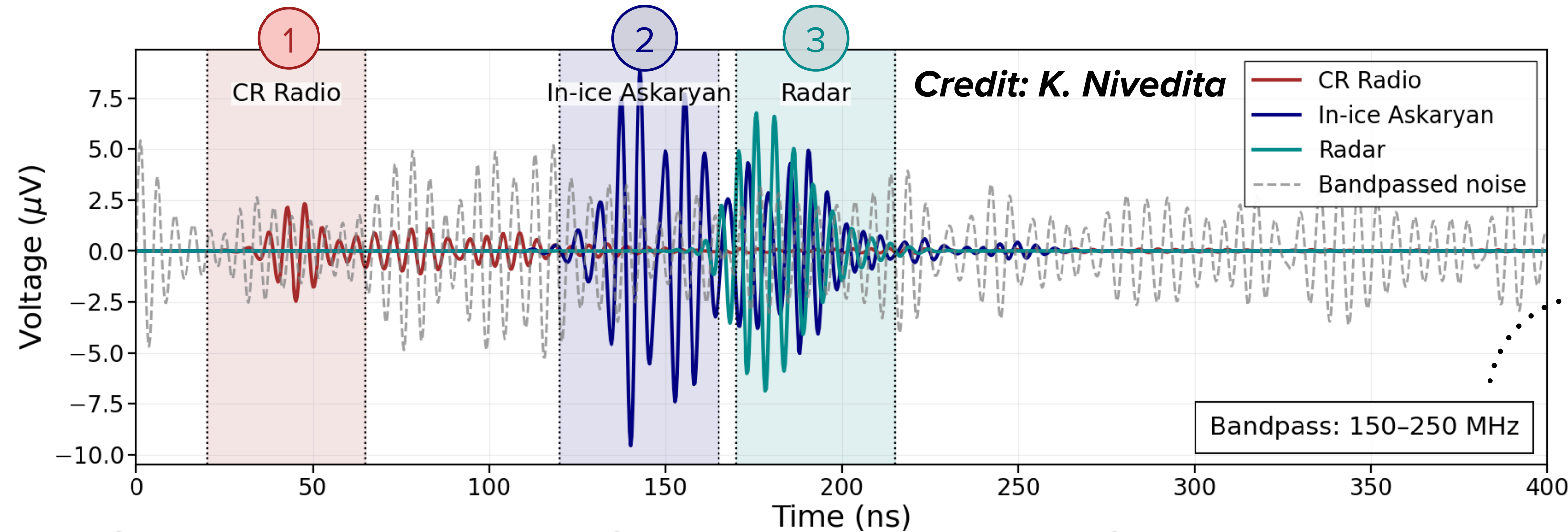


- In-air CR radio (x0.1)
- In-ice CR radio (x0.1)
- Radar, 544W (x10)



RET-CR Simulated Signals

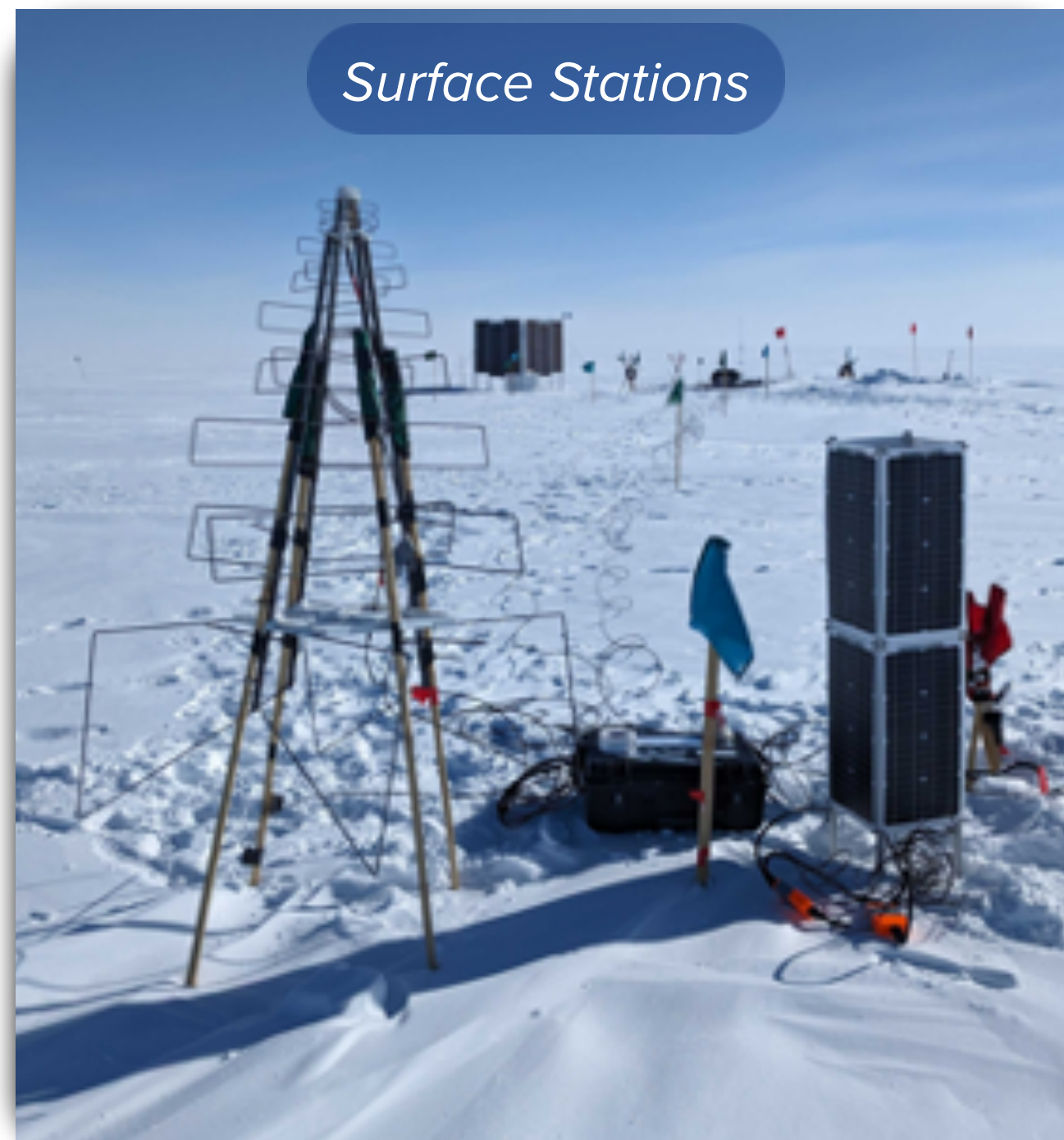
- ▶ Moving from electric fields to voltage estimates



- ▶ Can use timing and antenna bandwidths to distinguish different signal types

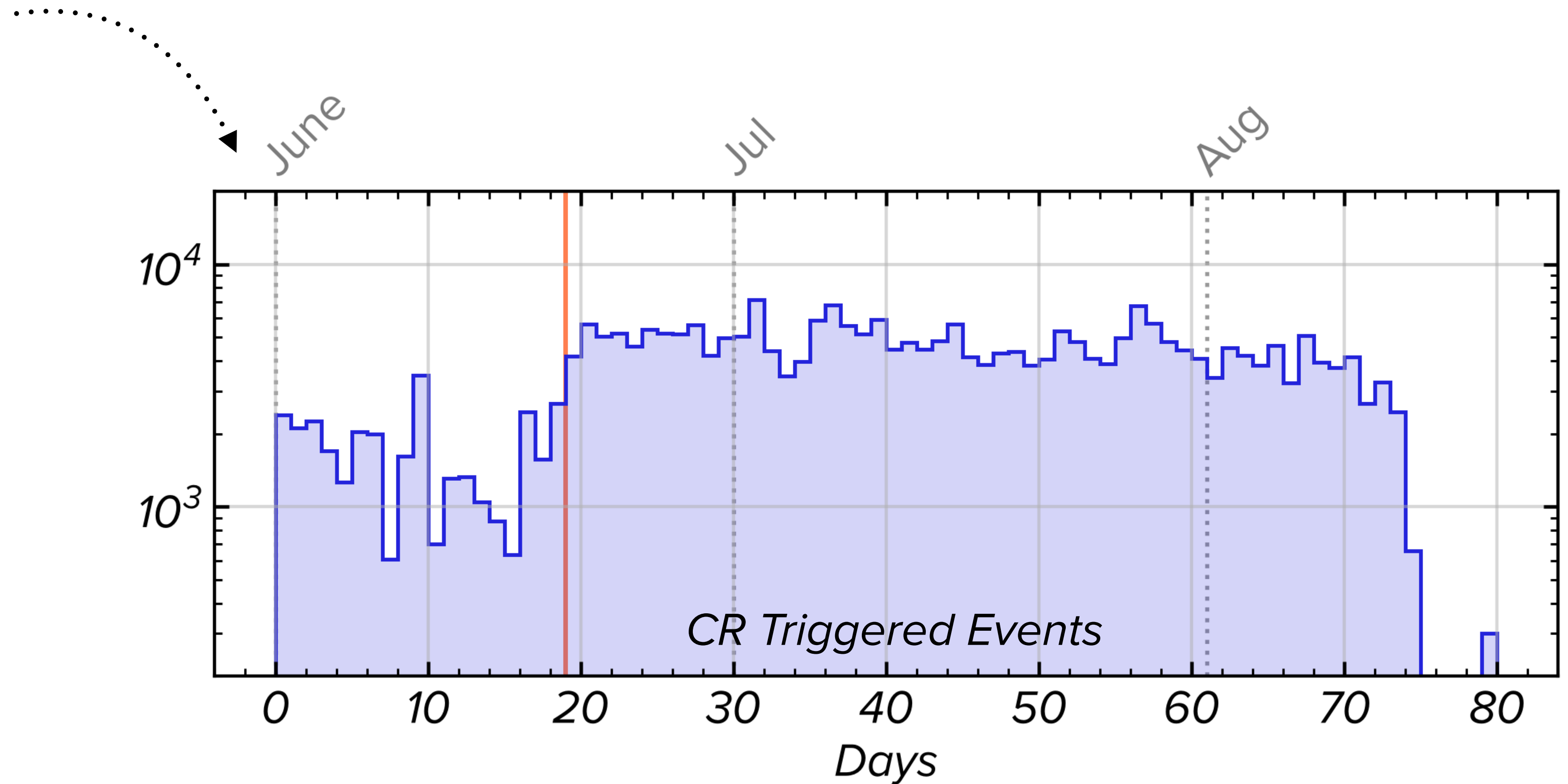
Surface Station Reconstruction

- ▶ RET-CR in 2024 ran for the full summer season



Surface Stations

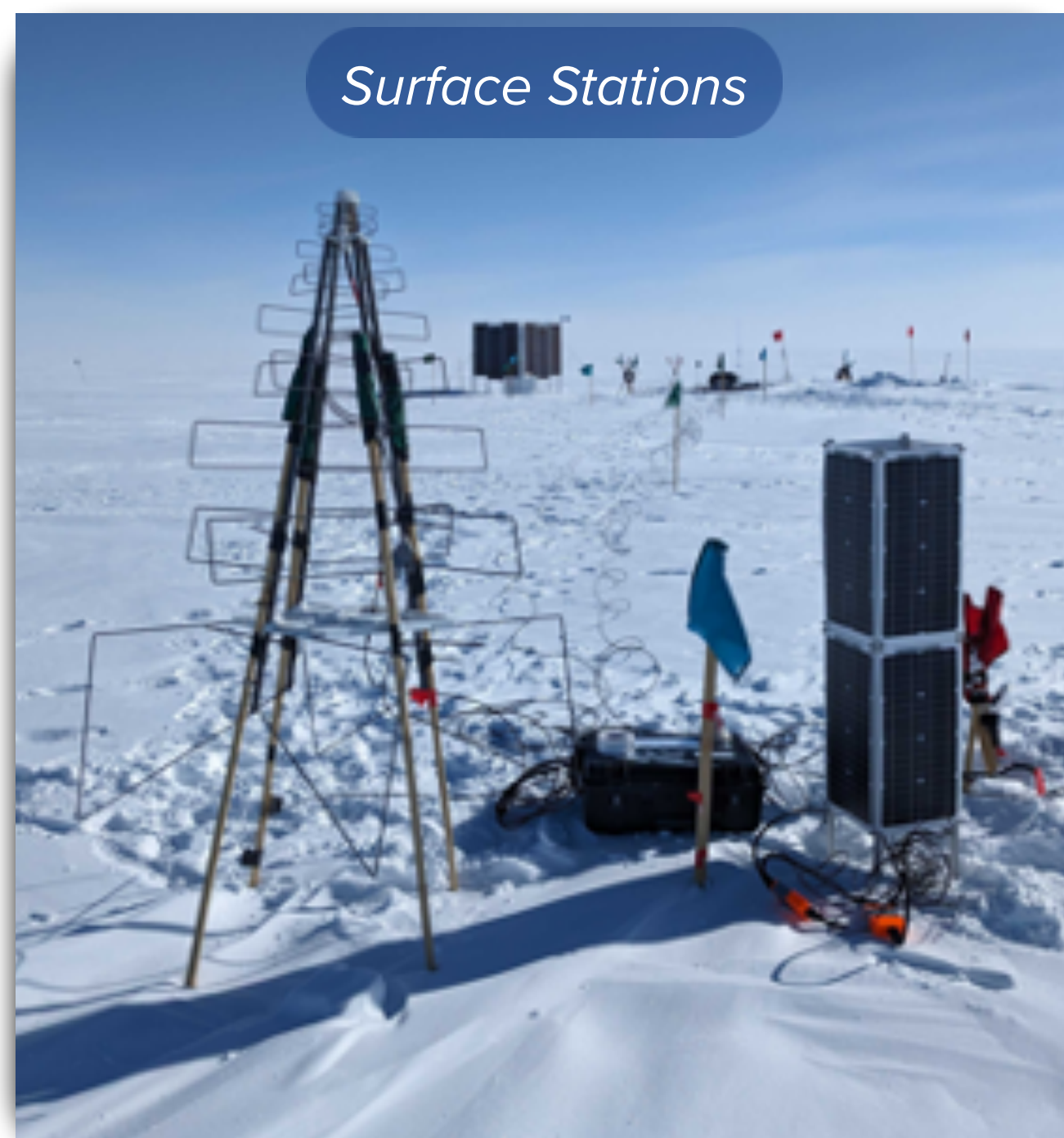
Picture credit: S. De Kockere



- ▶ Using 10% sample of full data set to explore analysis techniques

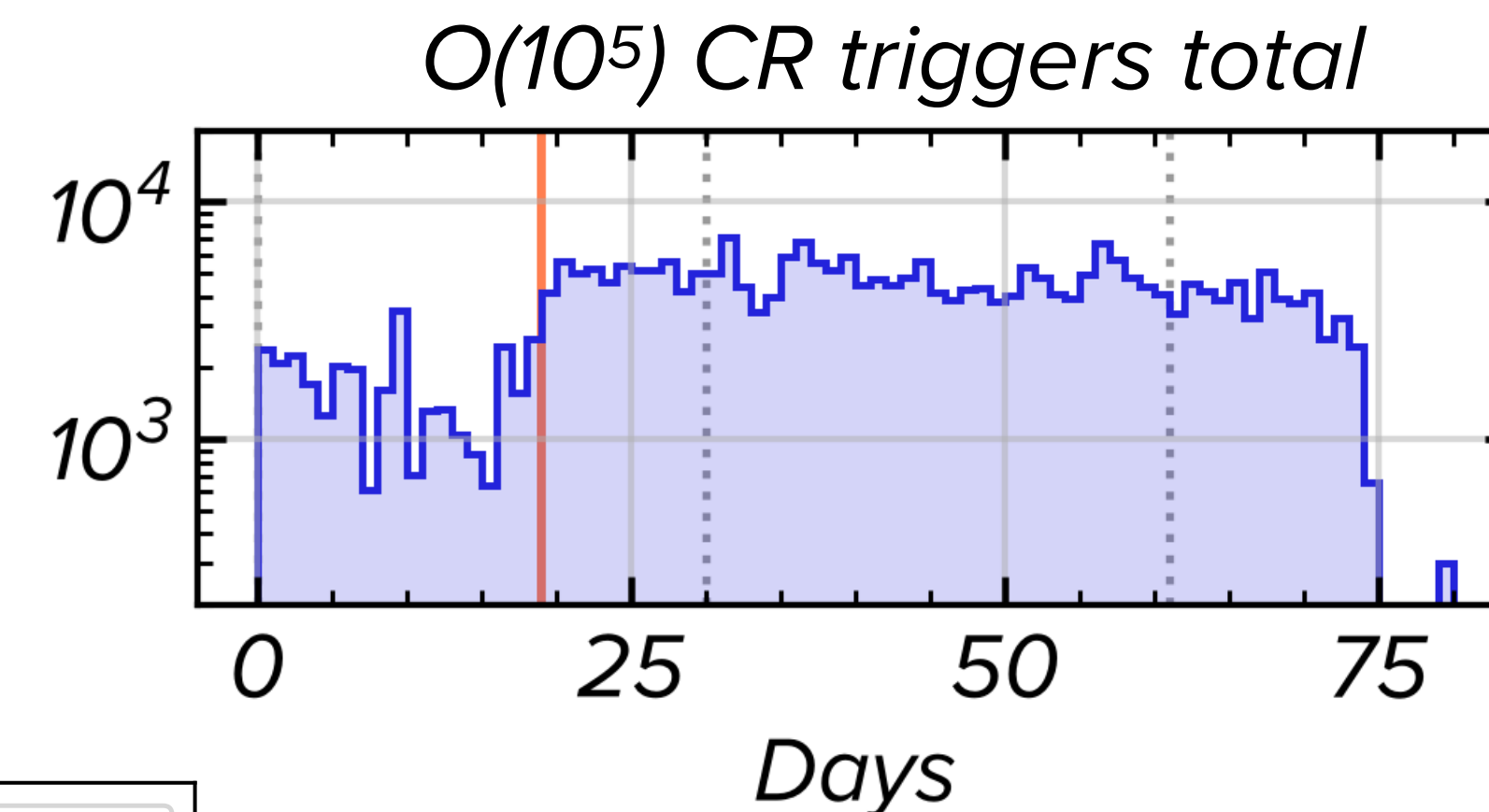
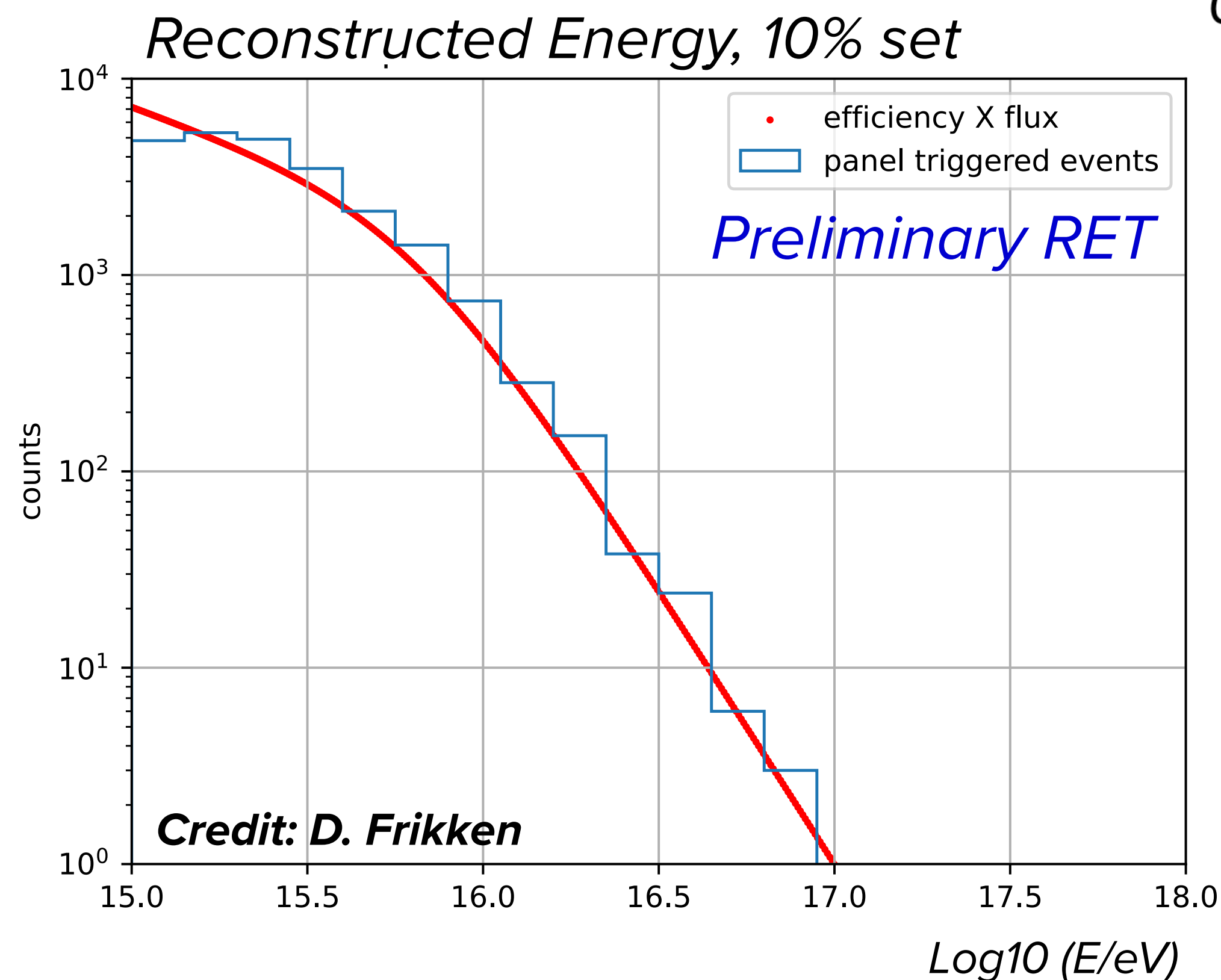
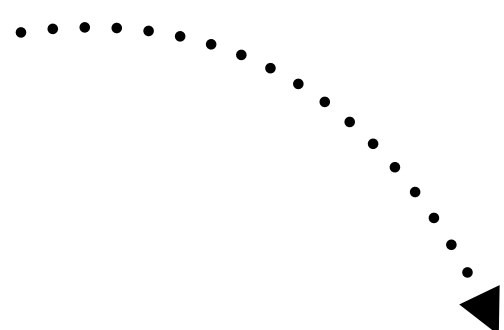
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Surface Stations

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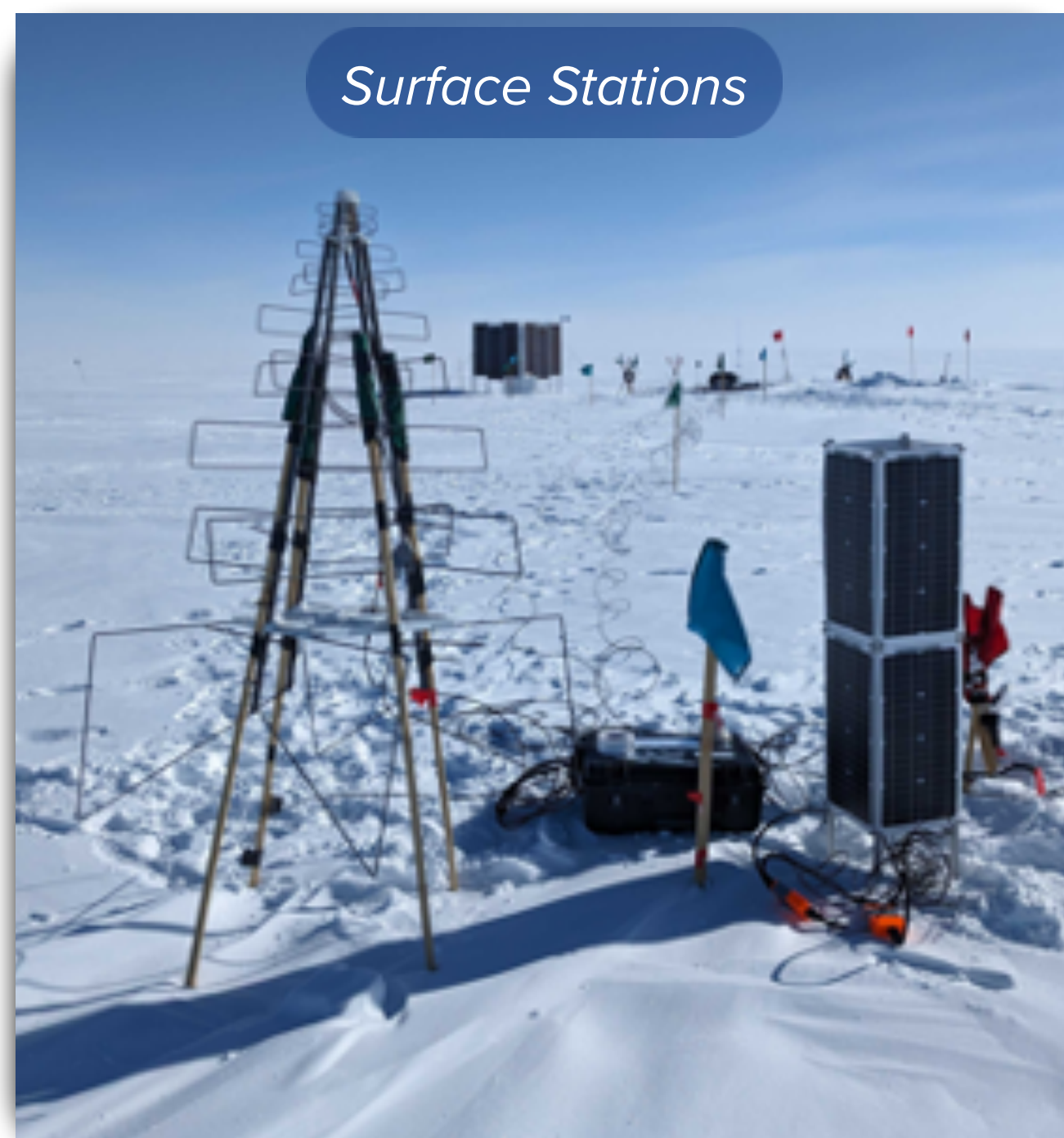


- ▶ In 10% set, expect 1.8 events with energies $E \geq 10^{17}$ eV
- ↓
- ▶ ~ 20 $E \geq 10^{17}$ eV events in the full set

→ K. Nivedita, PoS ICRC2025 (2025) 274

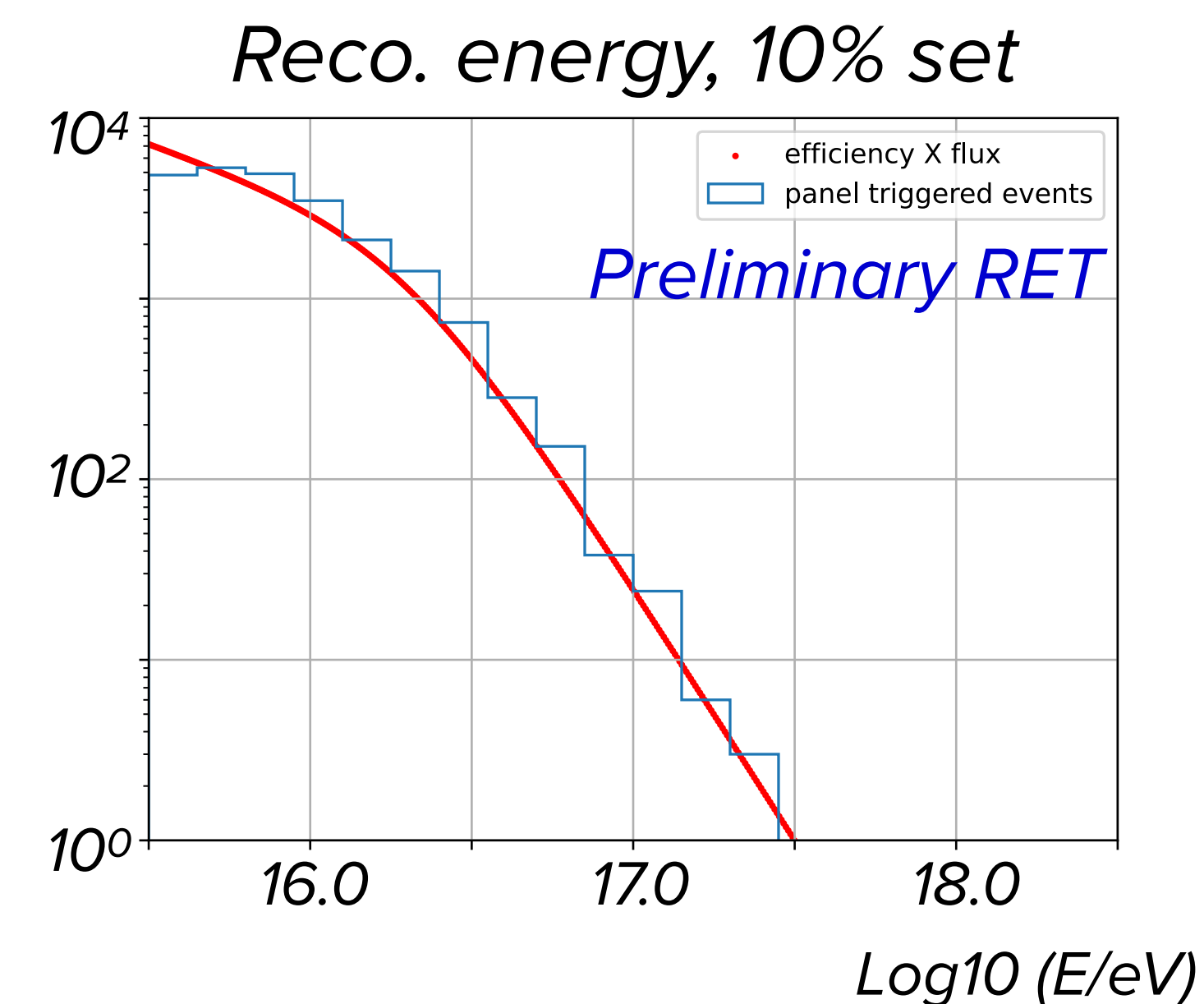
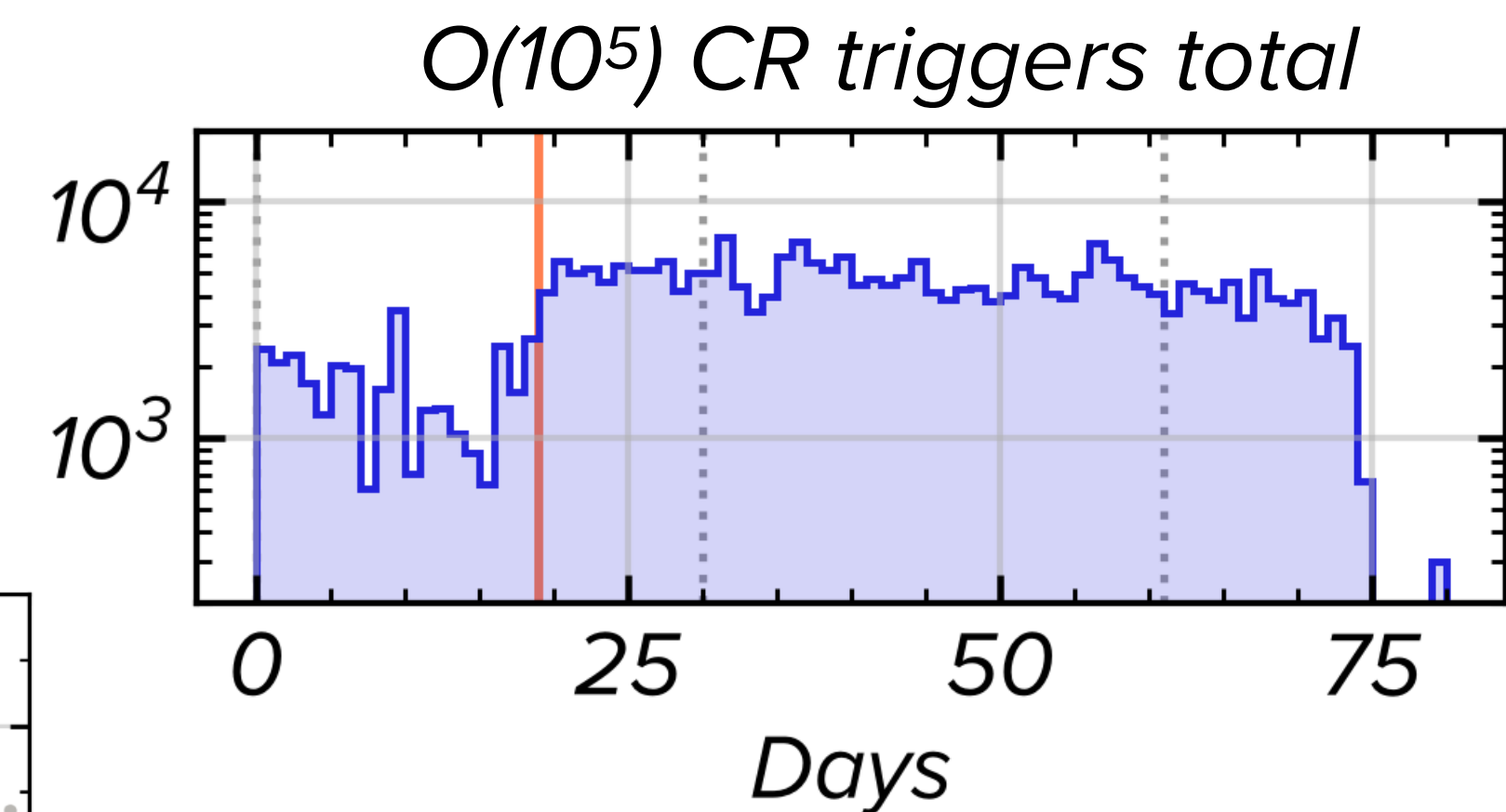
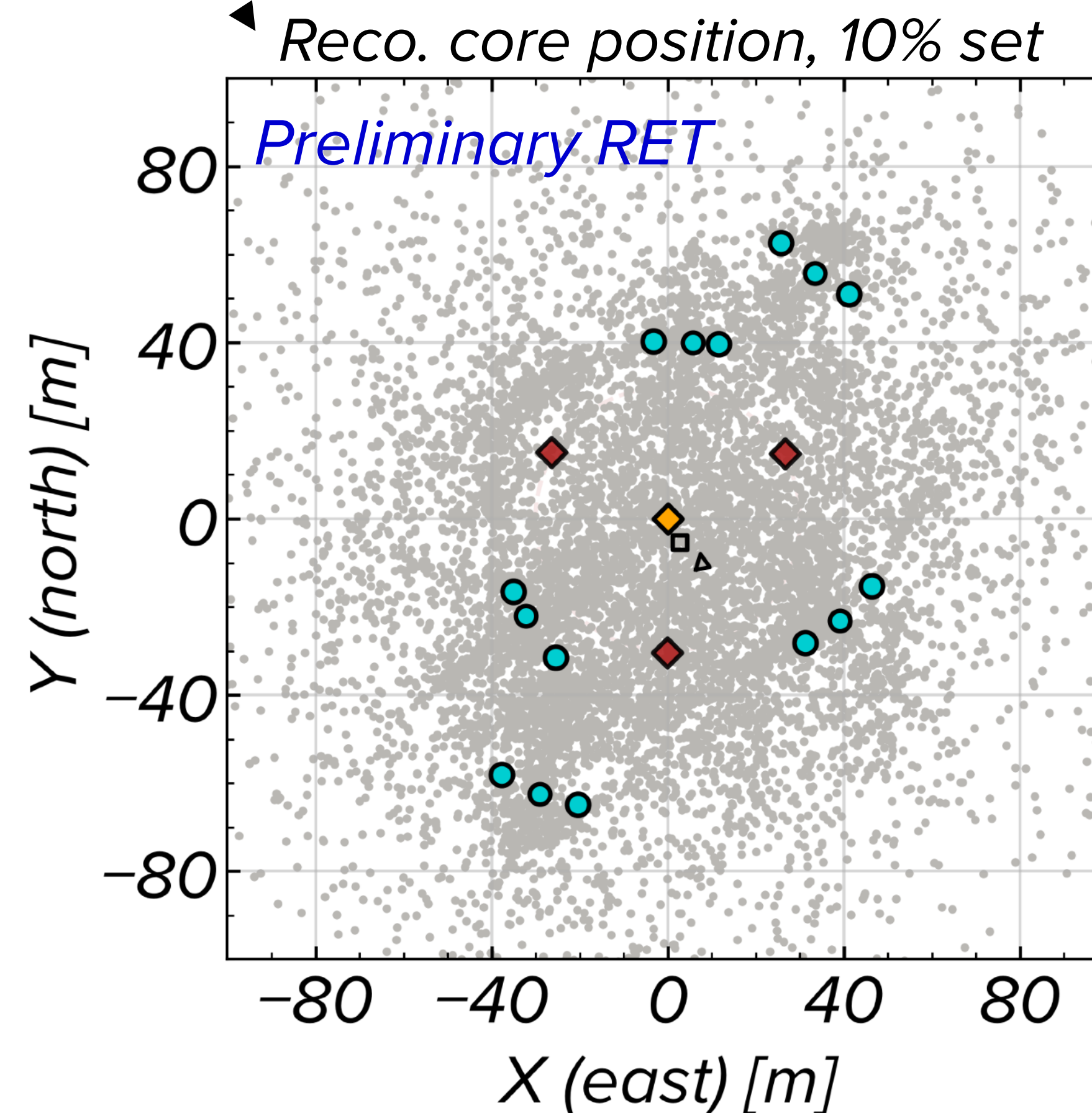
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Surface Stations

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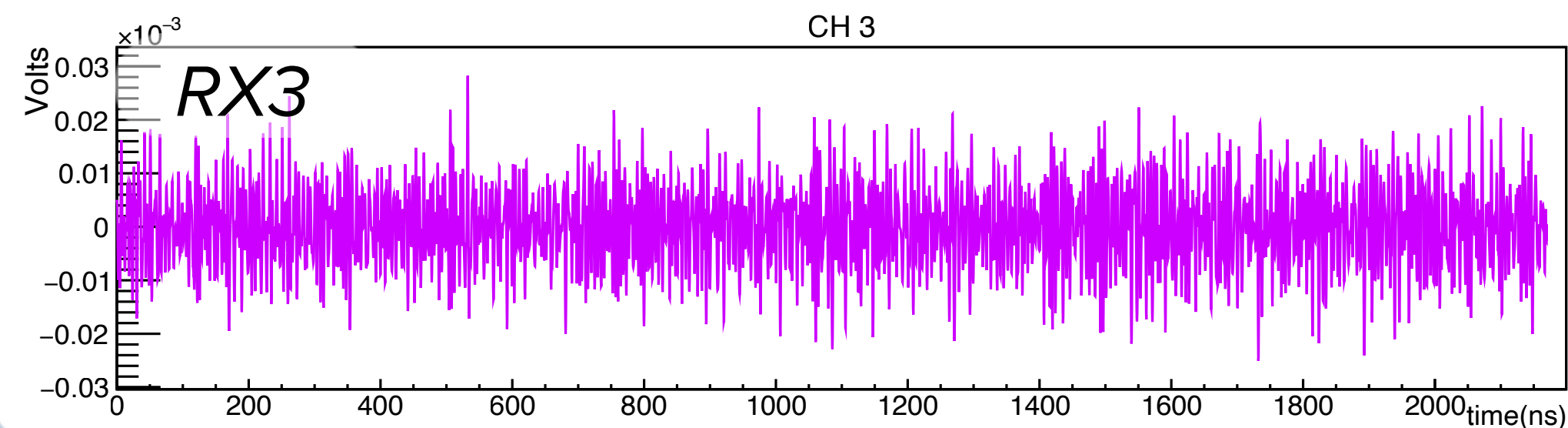
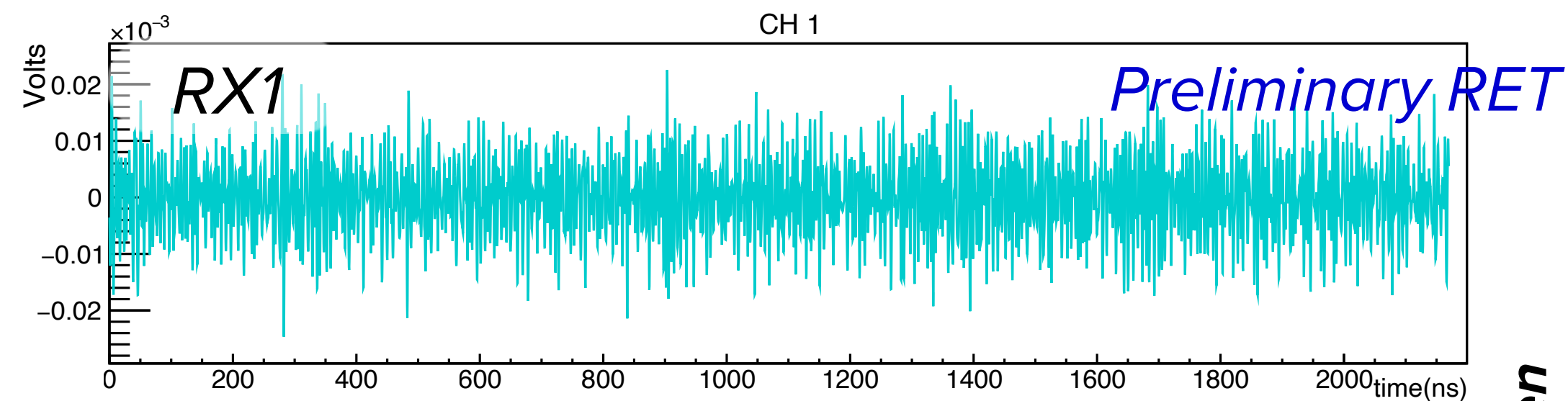
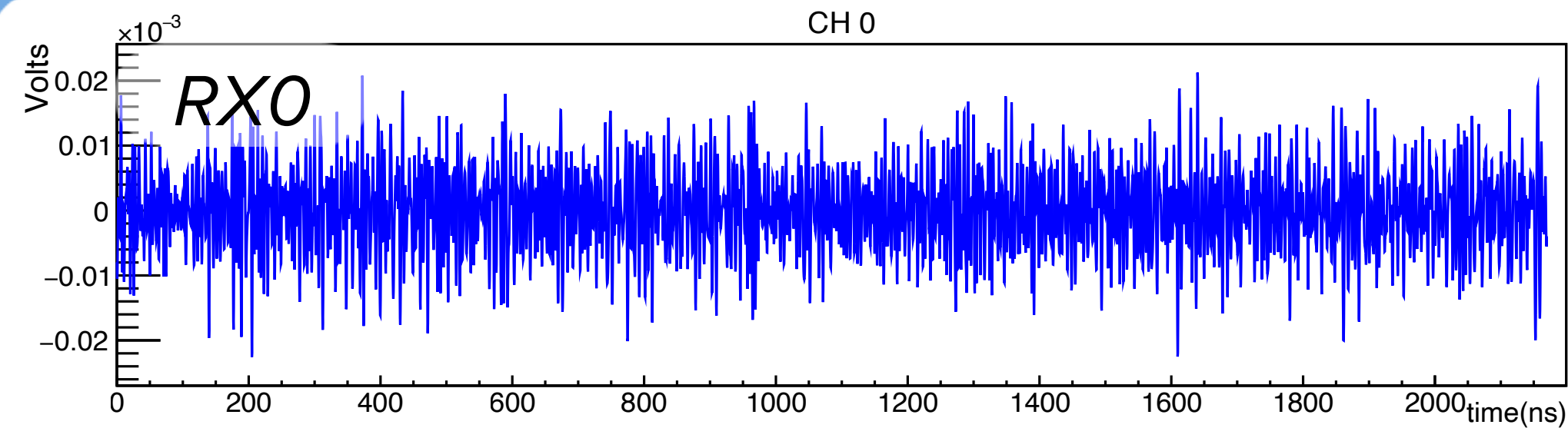


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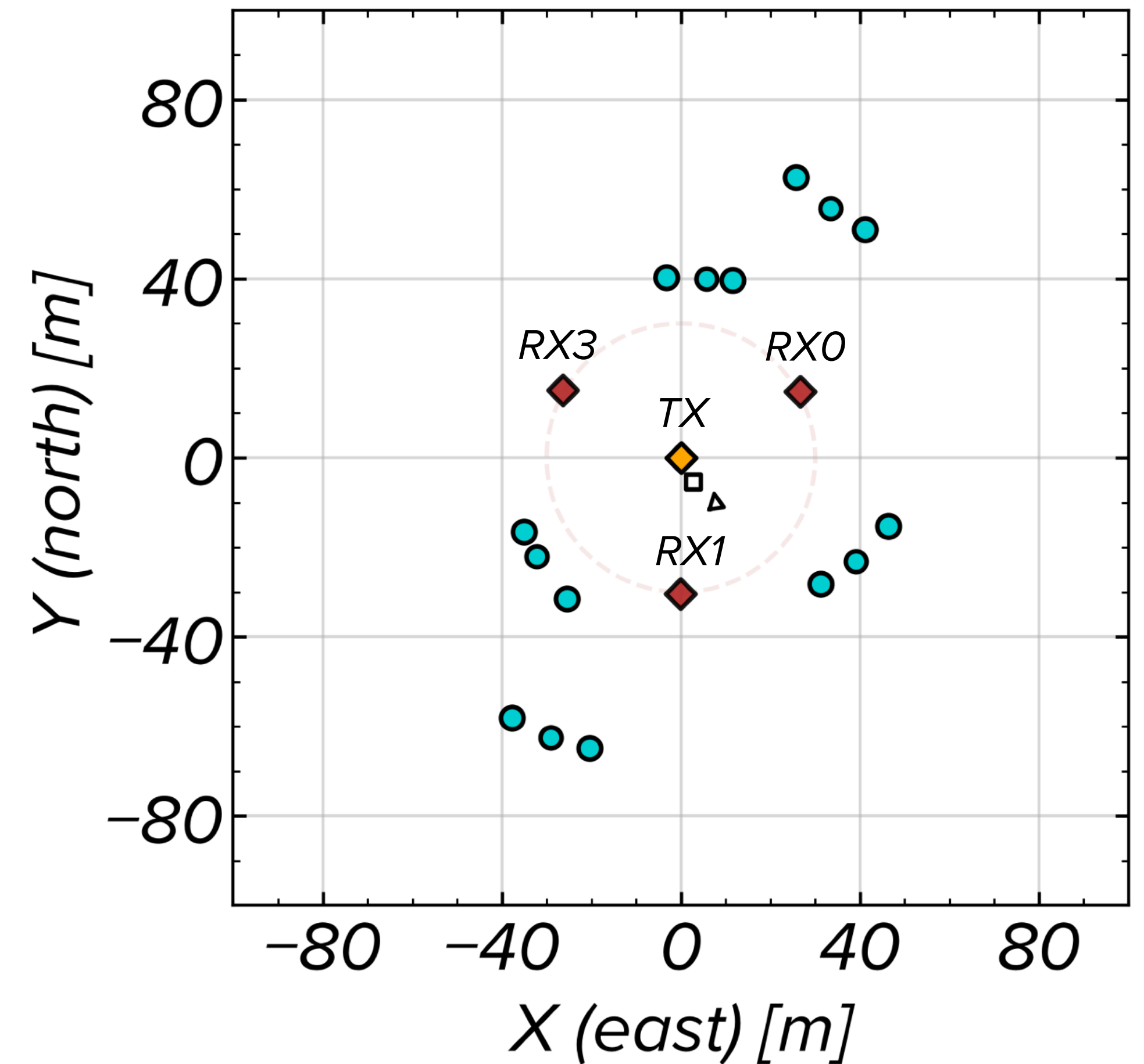
Exploring Radar Backgrounds

- Analysis of 2024 radar data is ongoing → *D. Frikken, PoS ICRC2025 (2025) 257*

Forced trigger event



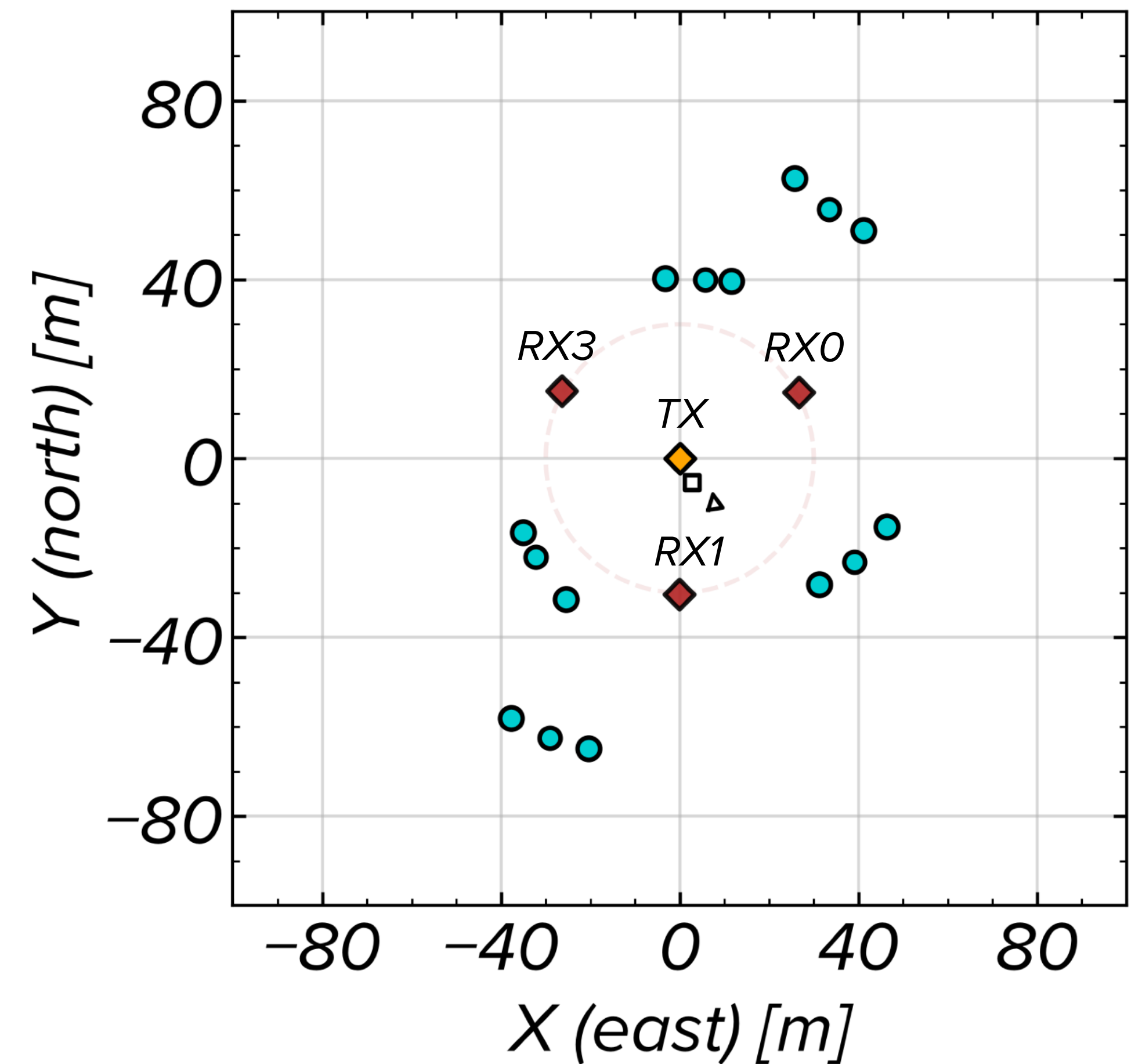
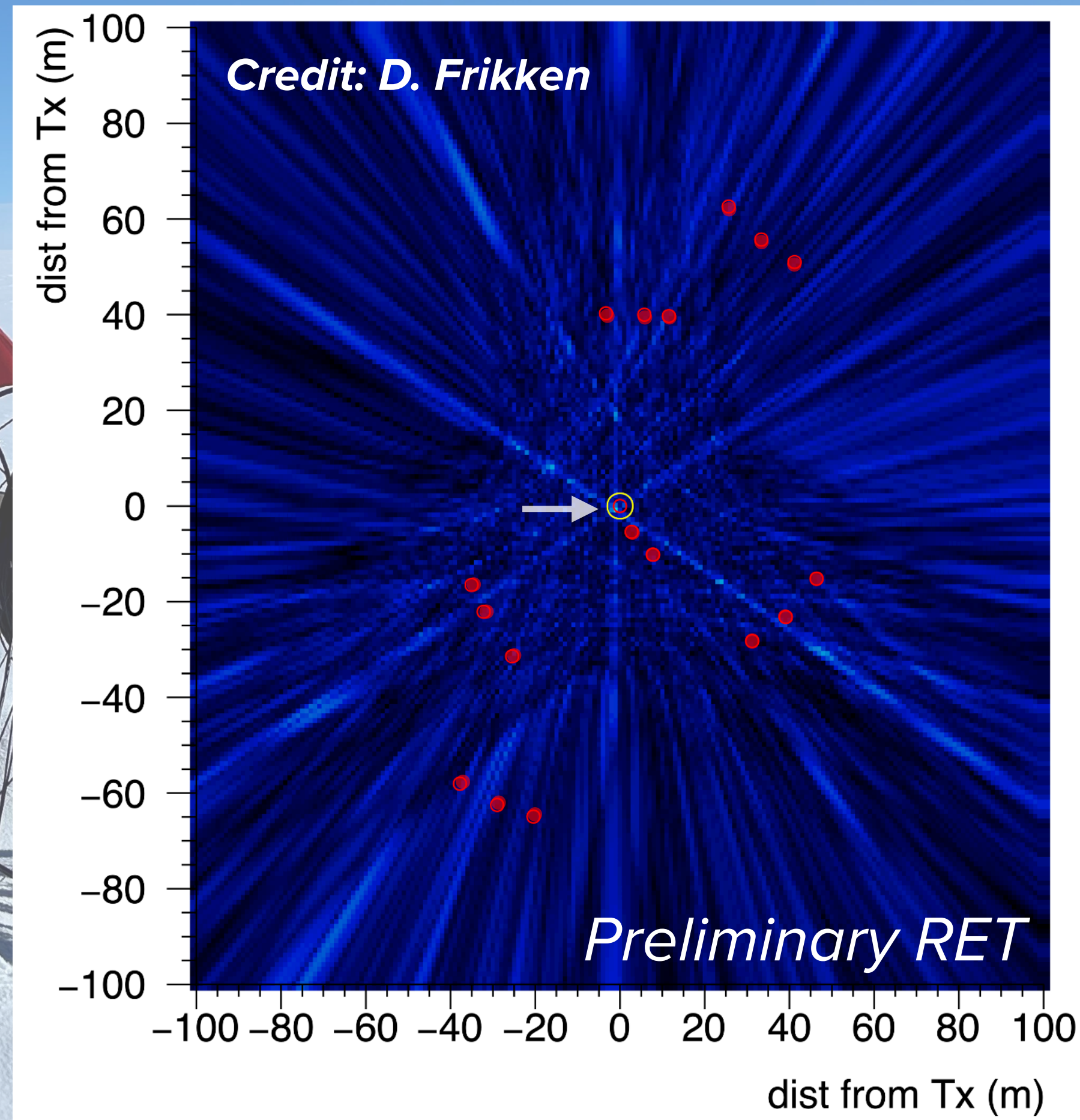
Credit: D. Frikken



Picture credit: S. Prohira

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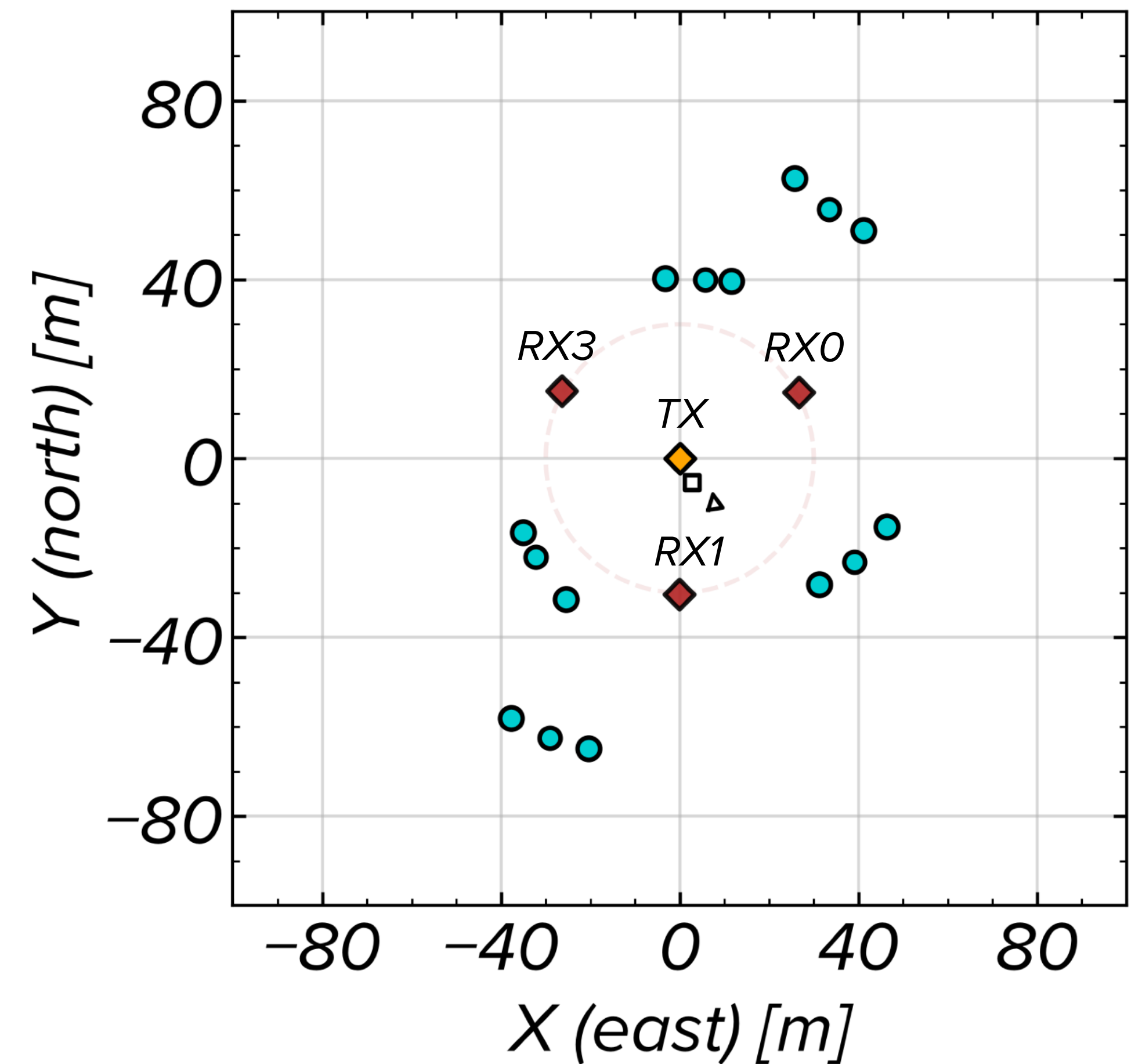
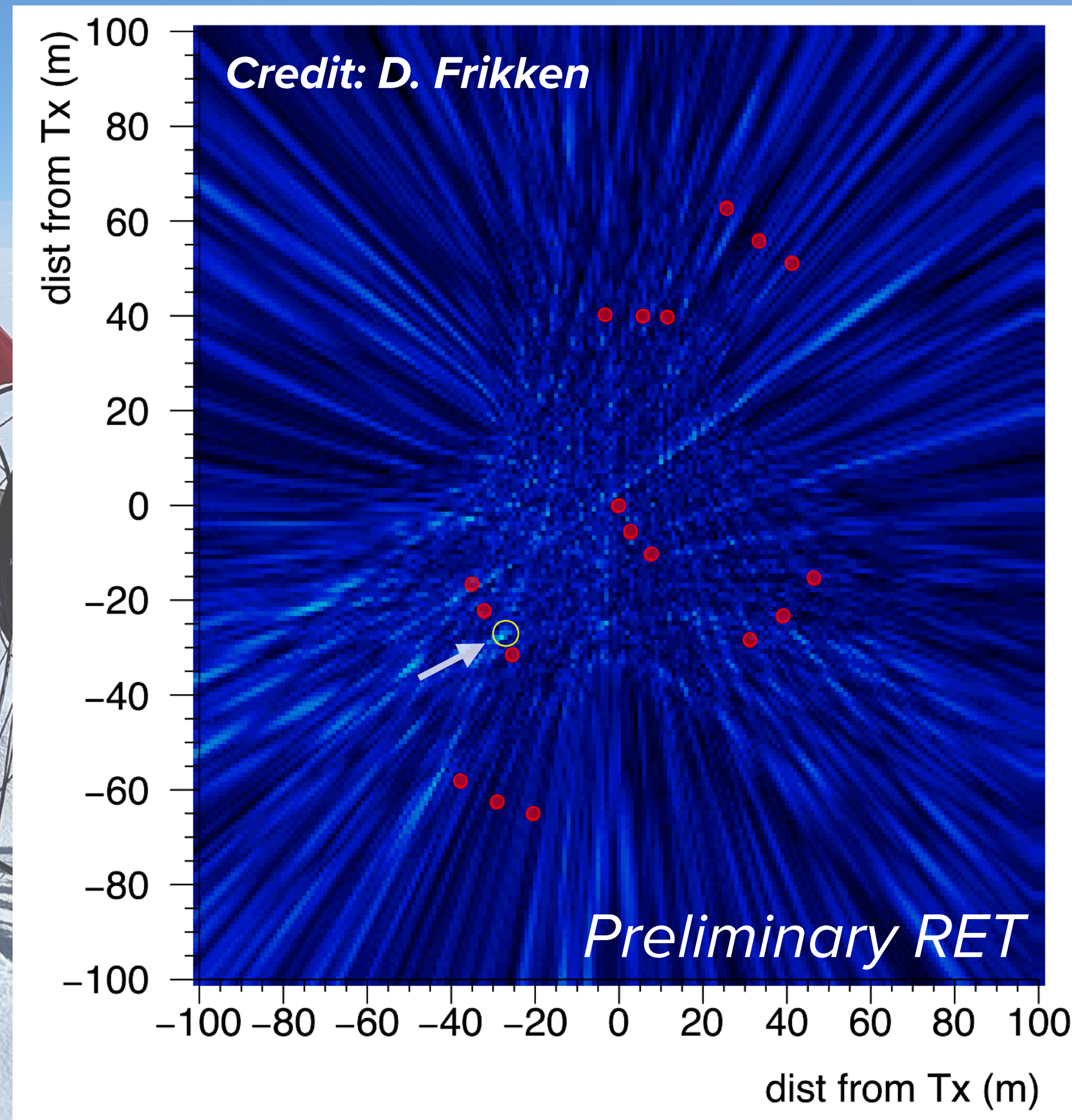


- Use cross-correlation search to investigate backgrounds

Picture credit: S. Prohira

Exploring Radar Backgrounds

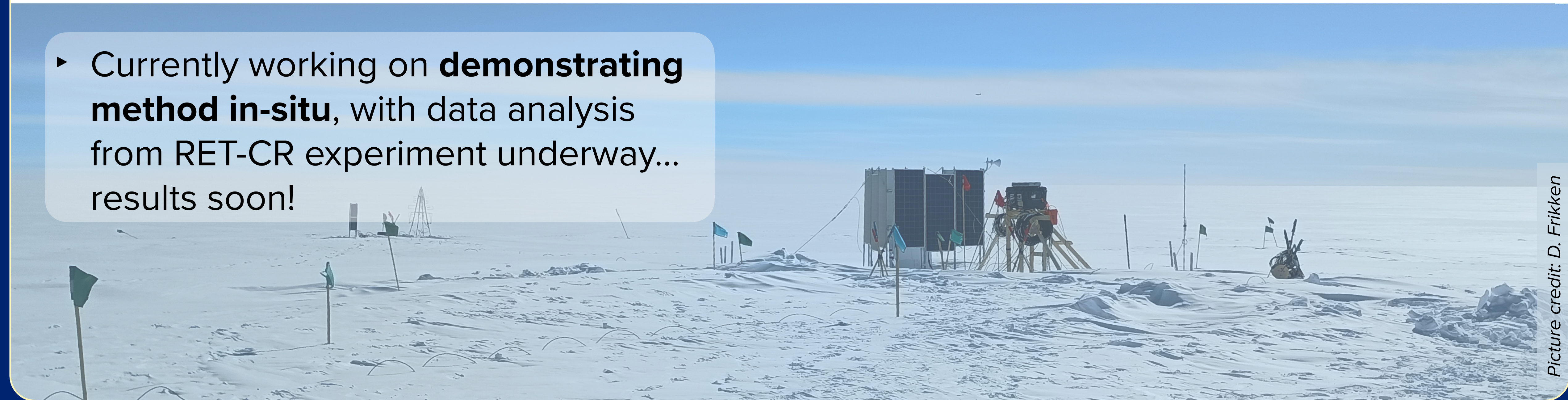
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Conclusions

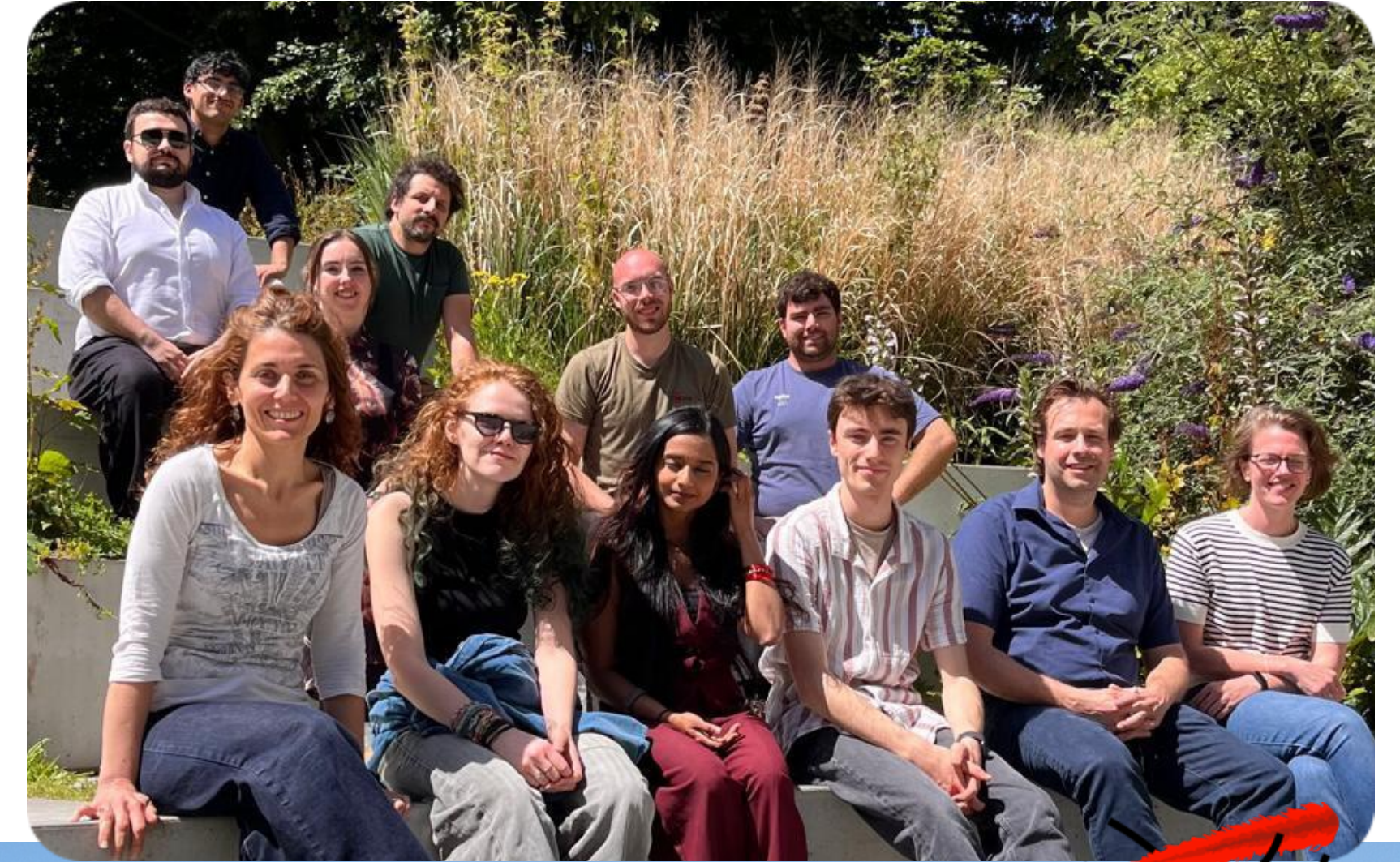
- ▶ Employing **radar** to detect **high-energy particles** interacting in ice
- ▶ Aim to use method to detect UHE cosmic neutrinos with **RET-N**
- ▶ Currently working on **demonstrating method in-situ**, with data analysis from RET-CR experiment underway... results soon!



Picture credit: D. Frikken

Conclusions

- ▶ Employing **radar** to detect **high-energy particles** interacting in ice
- ▶ Aim to use method to detect UHE cosmic neutrinos with **RET-N**



- ▶ Currently working on **demonstrating method in-situ**, with data analysis from RET-CR experiment underway... results soon!

RADAR ECHO TELESCOPE



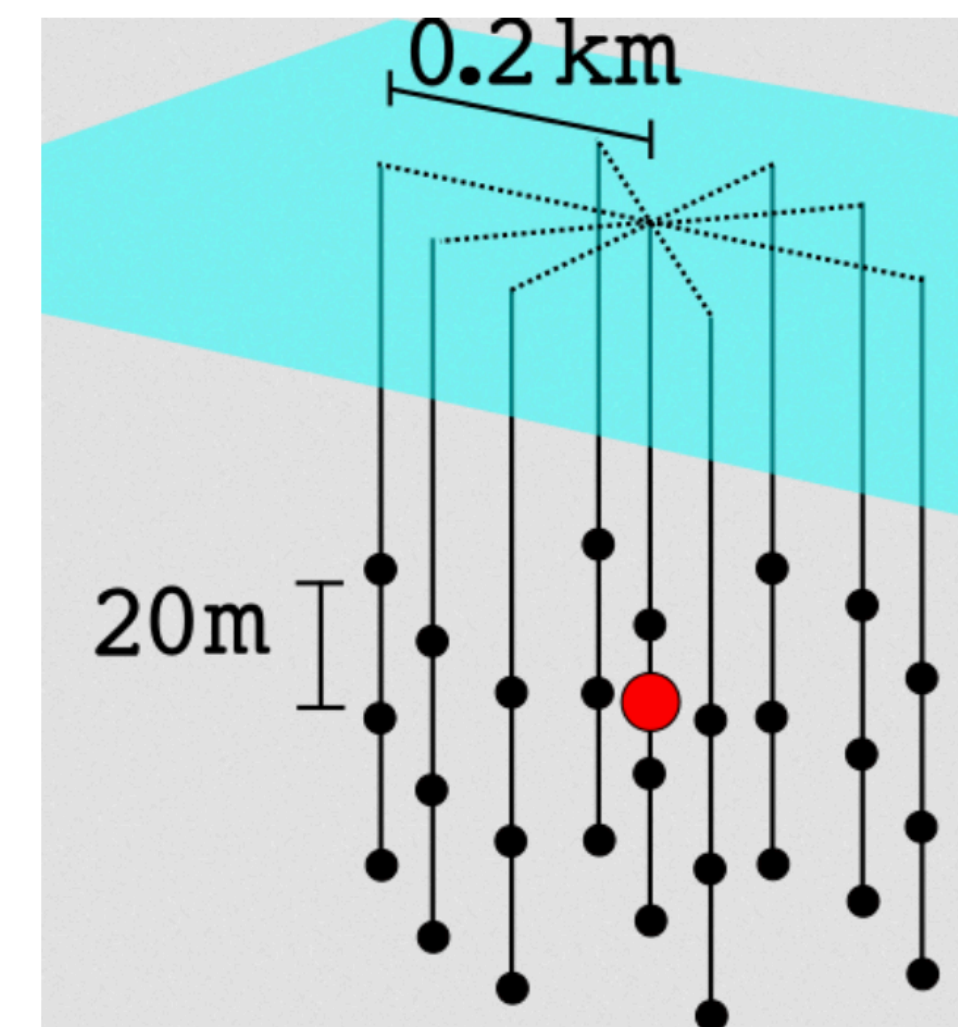
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DE BRUXELLES



Picture credit: D. Frikken

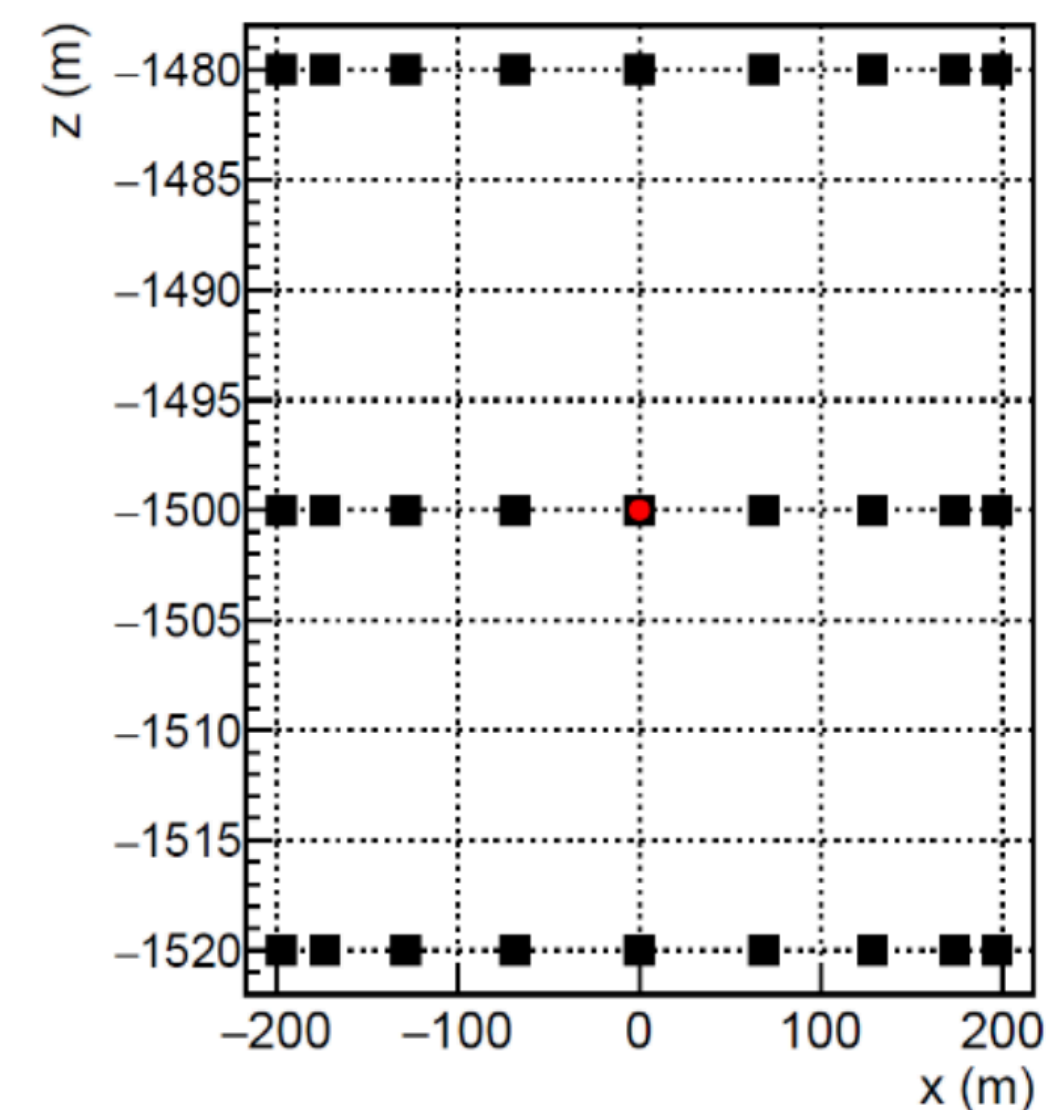
RET-N Preliminary Layout

- ▶ Preliminary RET-N detector layout
- ▶ 100kW x 10 stations:

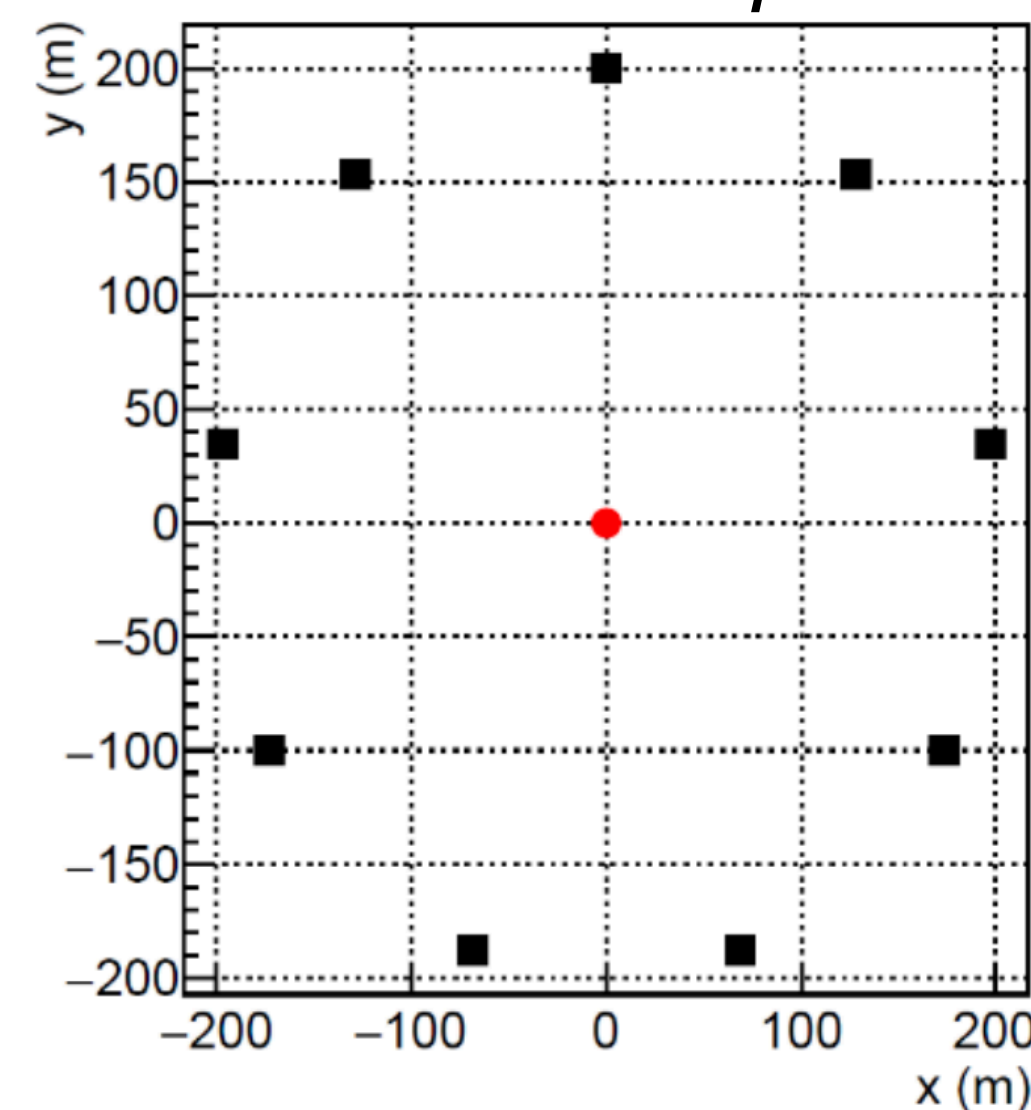


R. Stanley et al., 2022

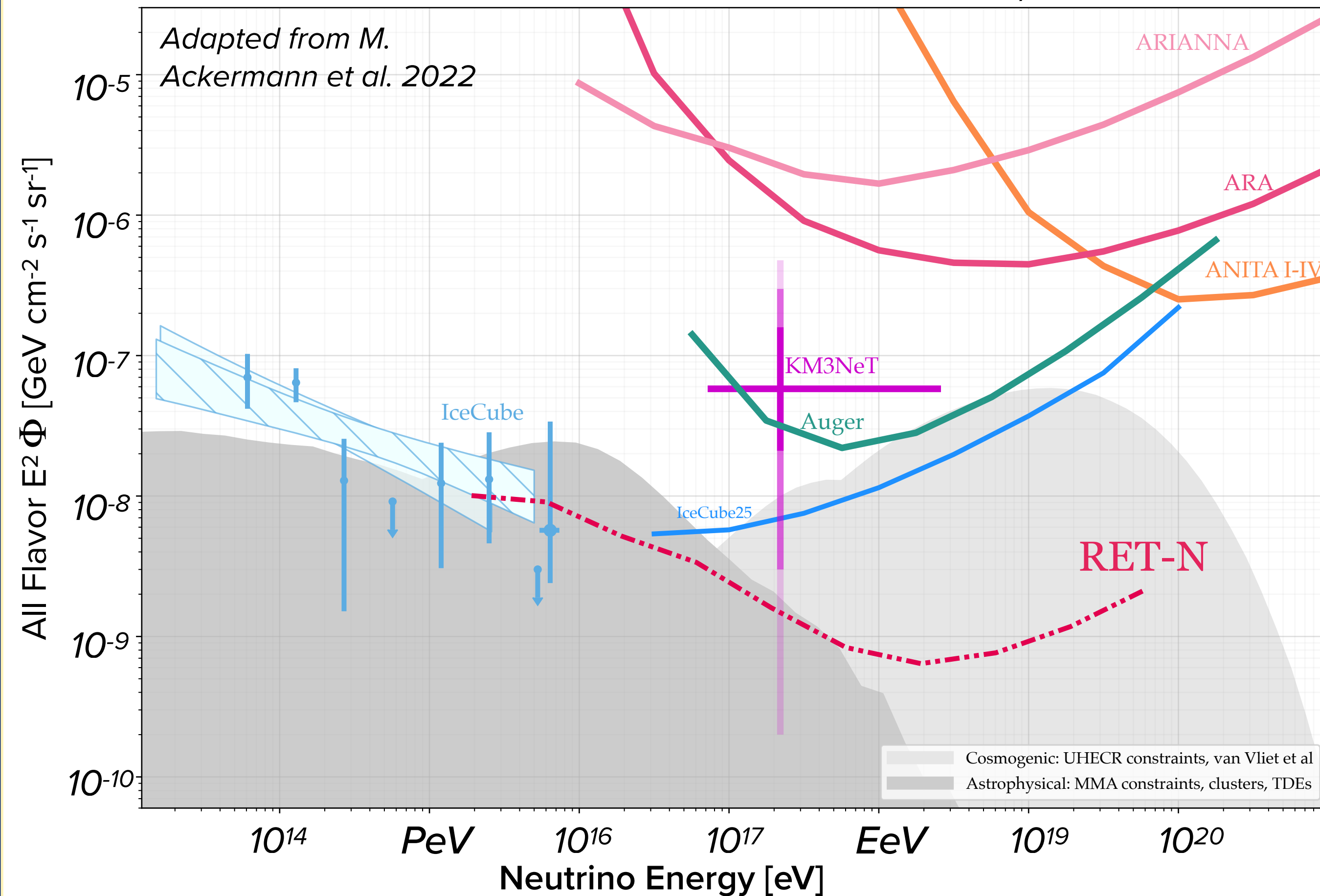
Station side view



Station top view

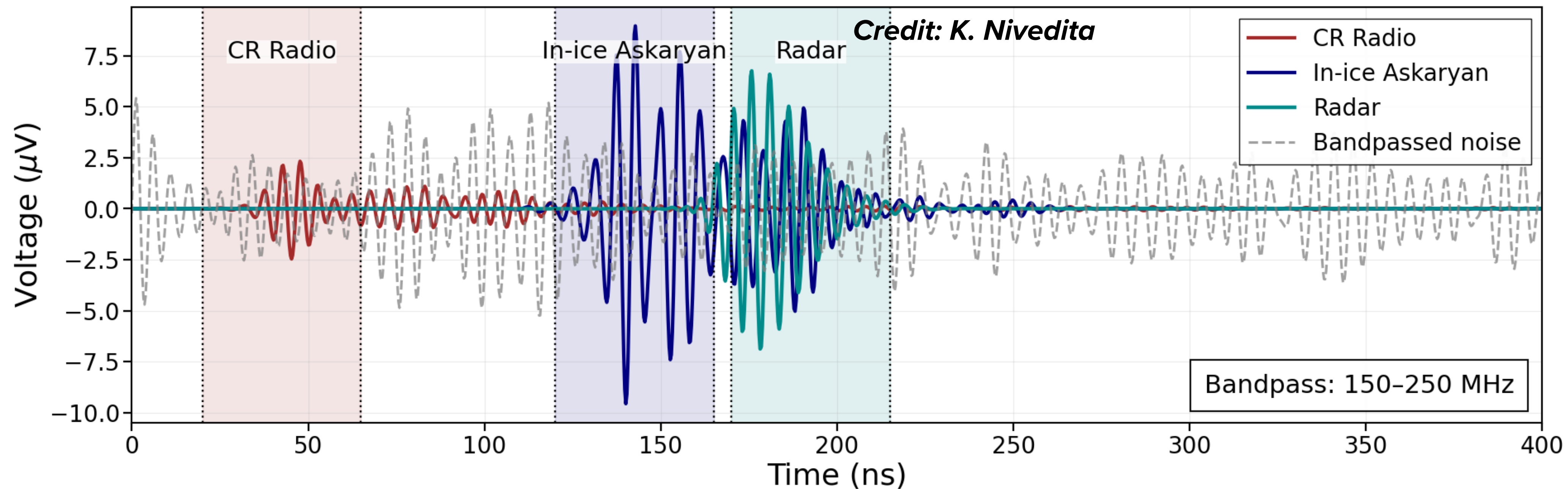


Diffuse flux, 1:1:1 Flavour Ratio



Combined RET-CR Signal Voltage Trace

- First-order voltage level comparison of RET-CR signals in the deployed detector



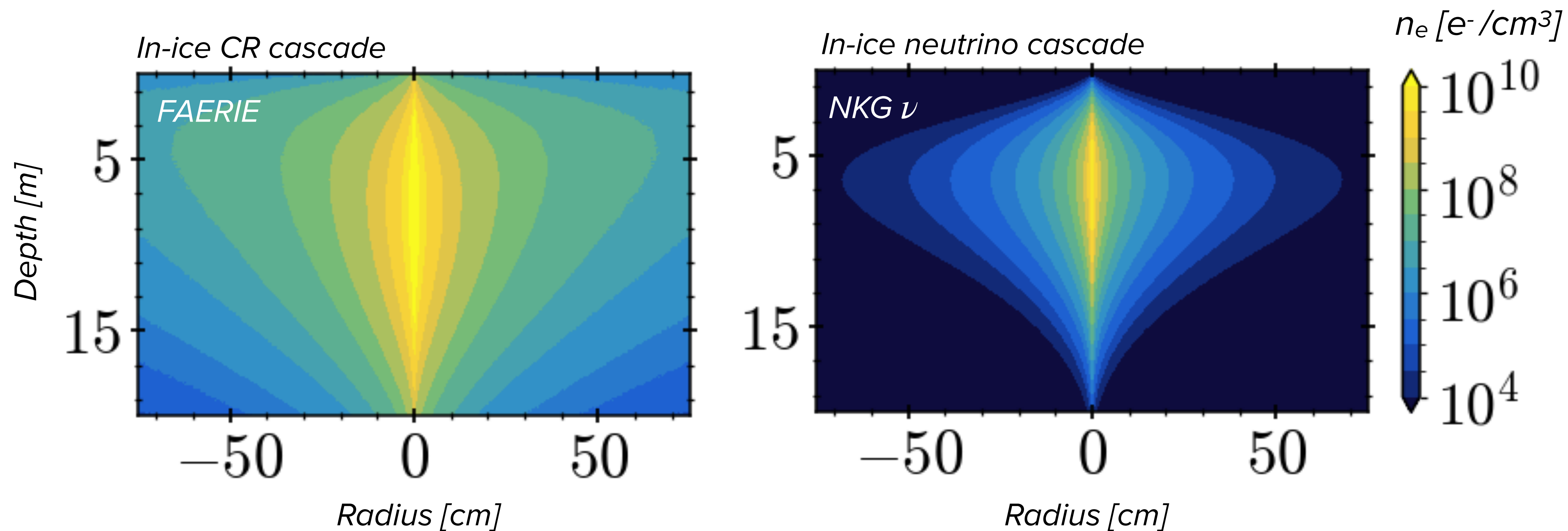
- Approximate dipole antenna response $\rightarrow L_{eff}(\Theta, \Phi) = \sin^2(\Theta)$
- 100-300 MHz bandpass filter matching antenna bandwidth
- Thermal noise contribution (Johnson-Nyquist noise), $V_{rms} = \sqrt{k_B T R \Delta f}$

$$\begin{aligned} T &= 290 \text{ K}, \\ R &= 50 \Omega, \\ \Delta f &= 100 \text{ MHz}. \end{aligned}$$

For more
details $\rightarrow$

*K. Nivedita et al., 2026
(arXiv:2607.24955)*

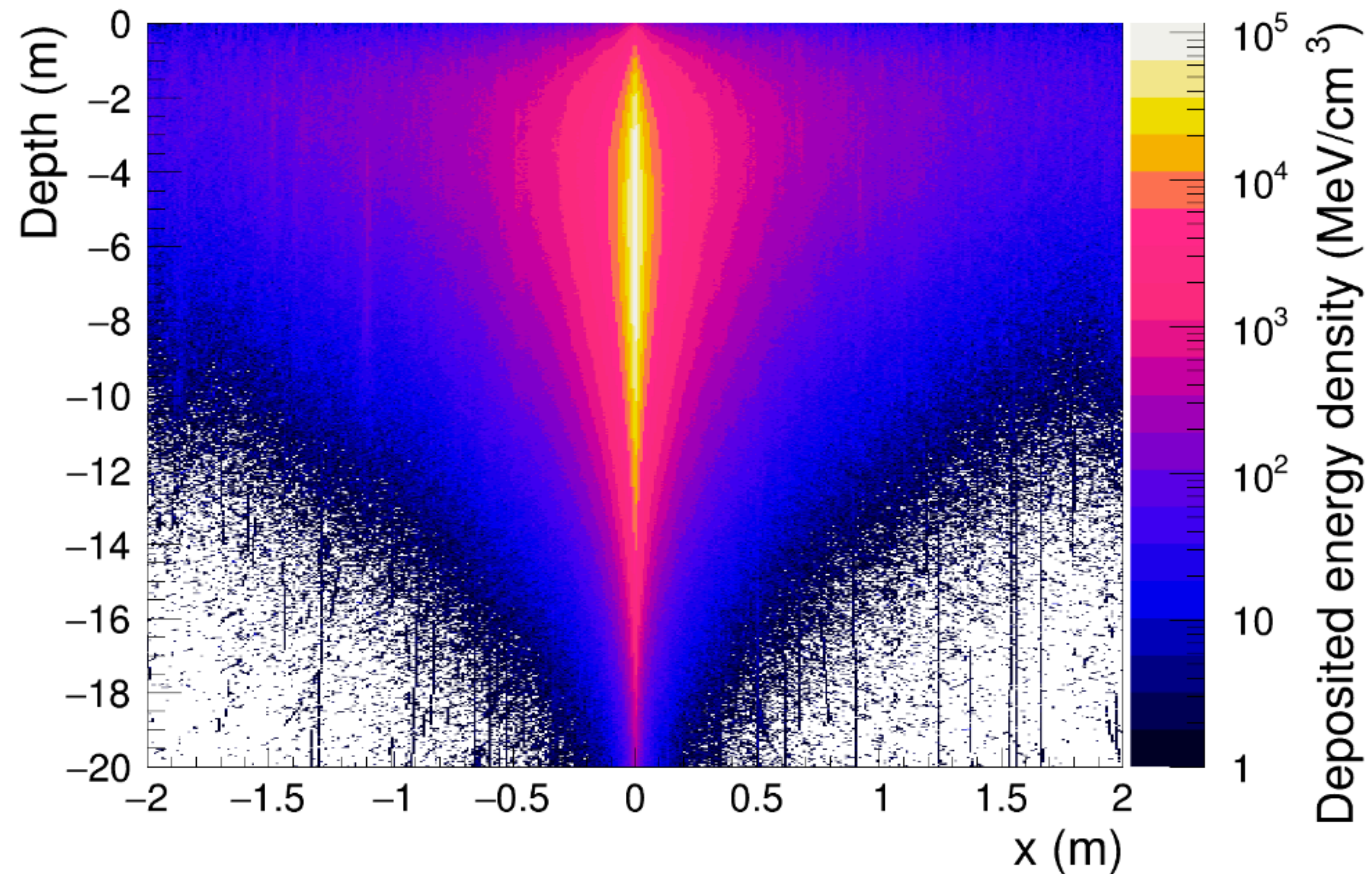
In-ice Cascades



- ▶ 17.0 eV, proton shower
- ▶ Greenland ice density

- ▶ ~ 1 PeV ν
- ▶ Constant ice density, 0.92 g/cm³

In-ice Cascades



S. De Kockere, K. D. de Vries et al. 2022

