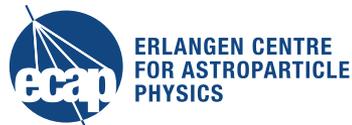


# Investigations of Ice (and Emitter) Properties from Radio Signals Recorded with ARIANNA

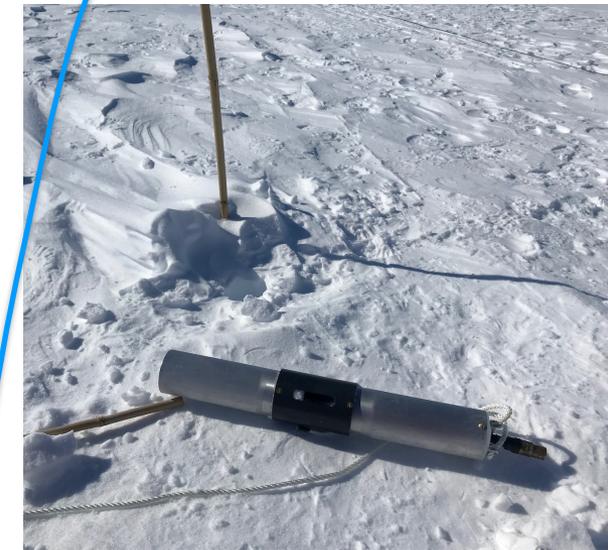
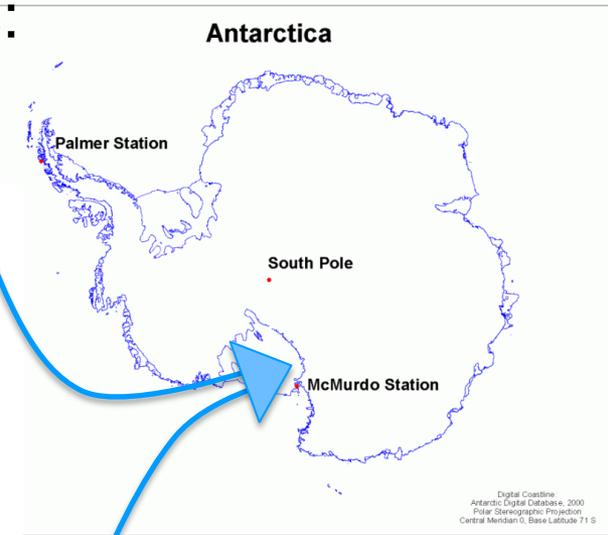
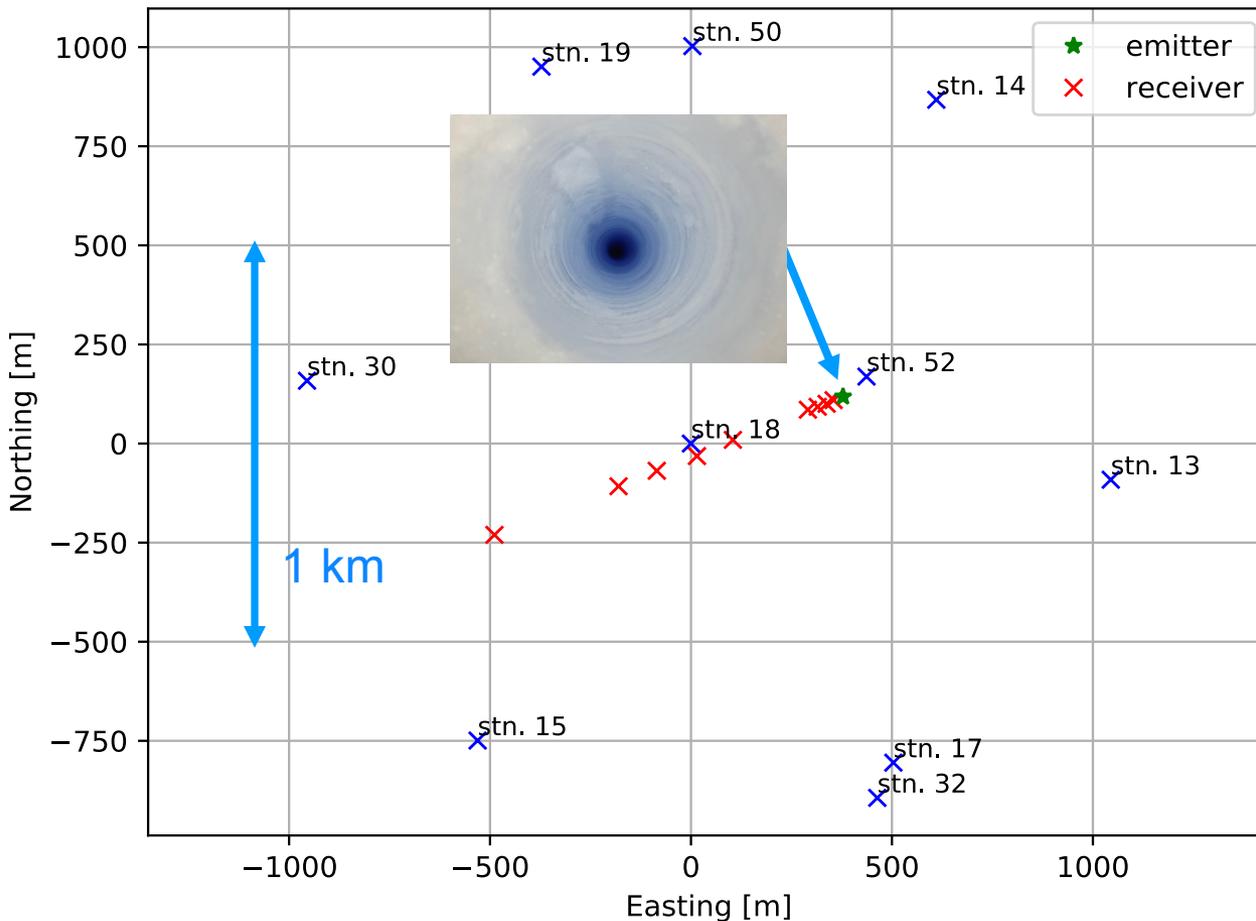
ERLANGEN CENTRE  
FOR ASTROPARTICLE  
PHYSICS

Robert Lahmann  
ICRC 2019

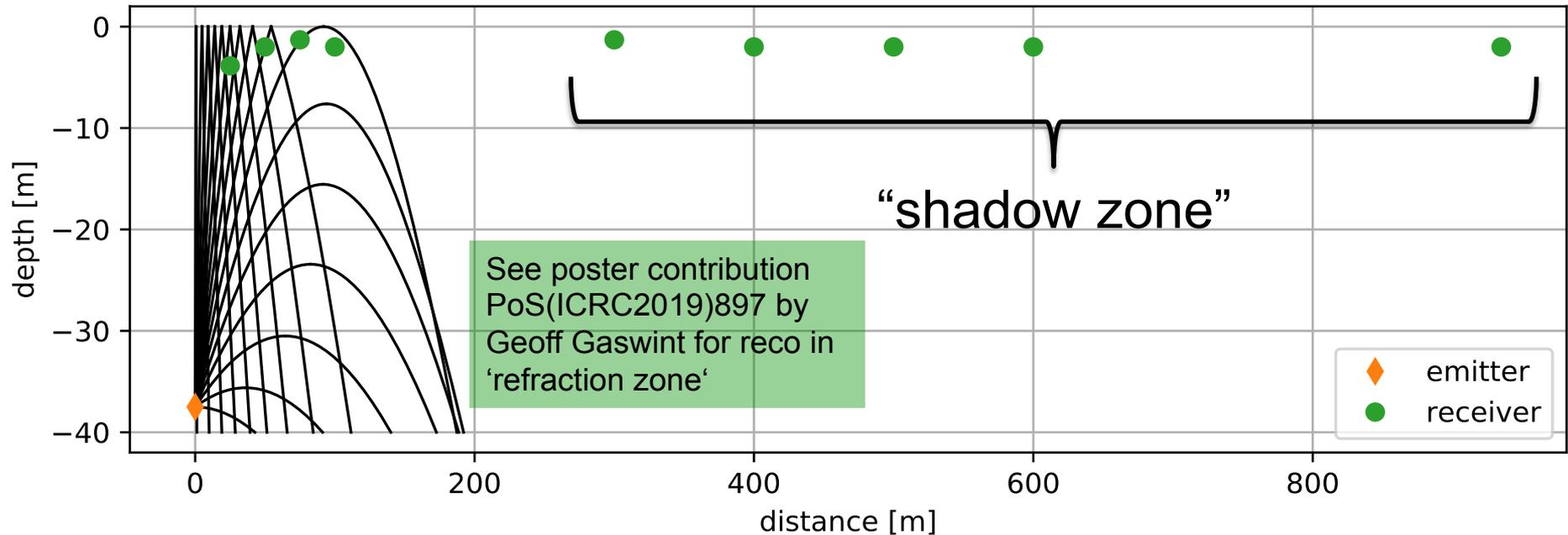


# ARIANNA Radio Detector at Moore's Bay

2018/19 Antarctic season measurements:  
Dipole radio emitters and receivers  
arranged at distances from 25m to 1km



# Investigation of the ‘Shadow Zone’



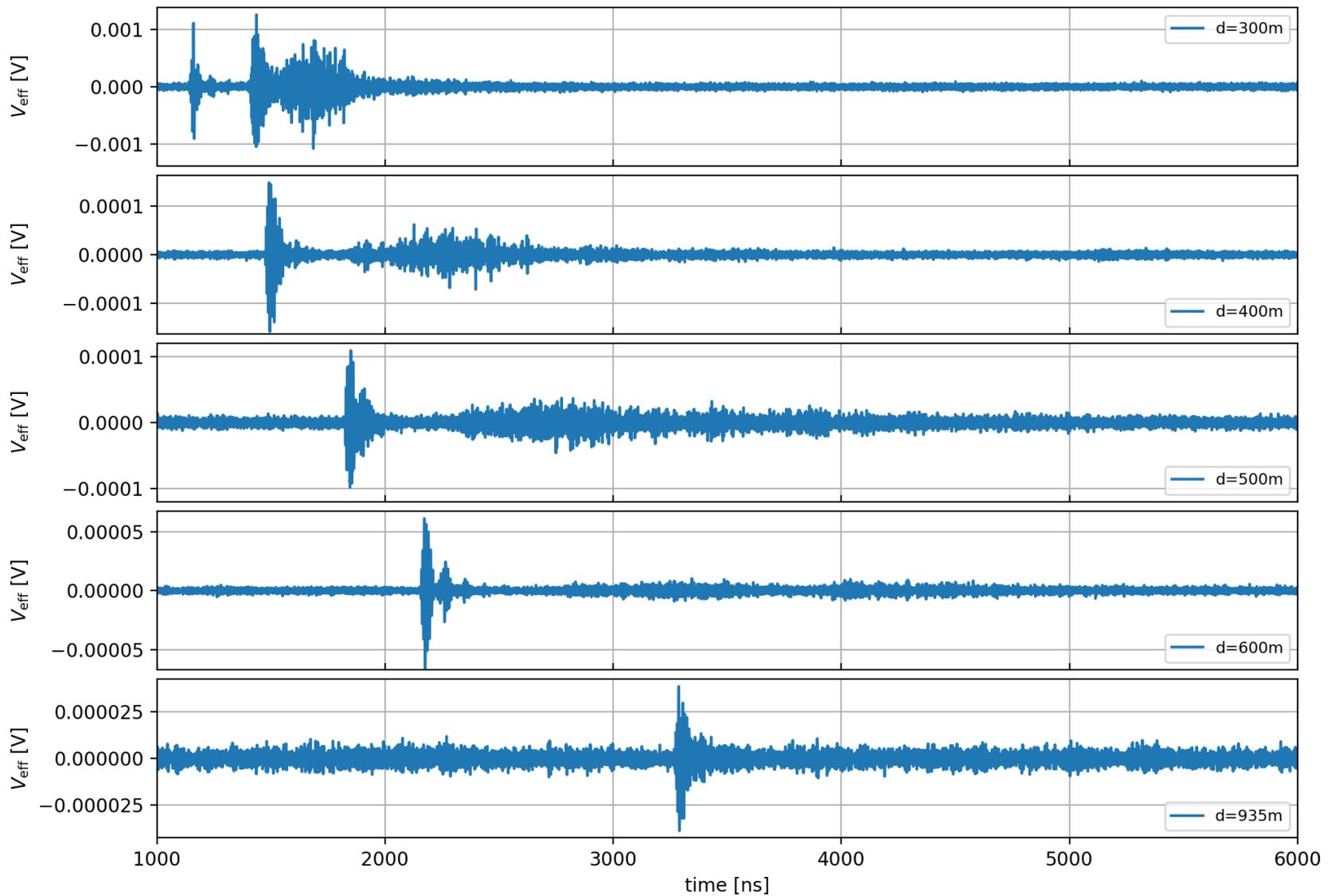
## Why investigate the ‘shadow zone’?

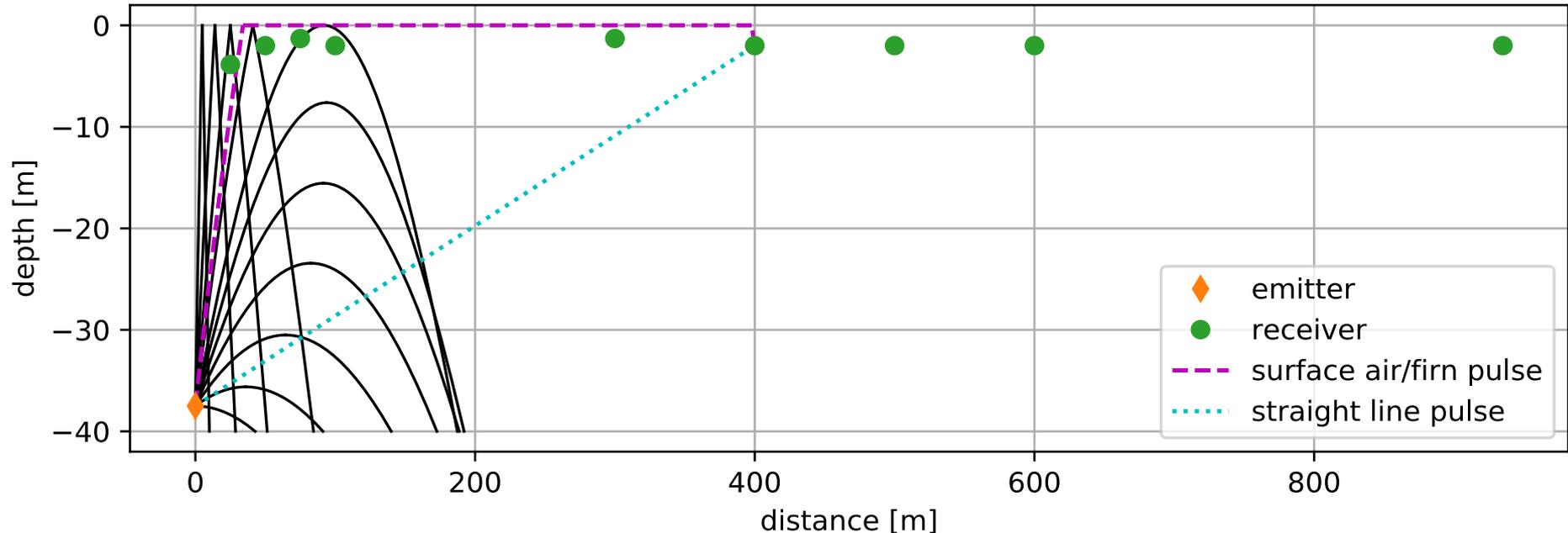
- Signals observed in the shadow zone in measurements at Moore’s Bay, South Pole, Greenland → ‘universal effect’
- Potential to increase effective volume
- Potential to provide add’l information for energy and vertex reconstruction from signals observed in ‘refraction zone’



# Vpol – Vpol Configuration

# Time Traces in Shadow Zone

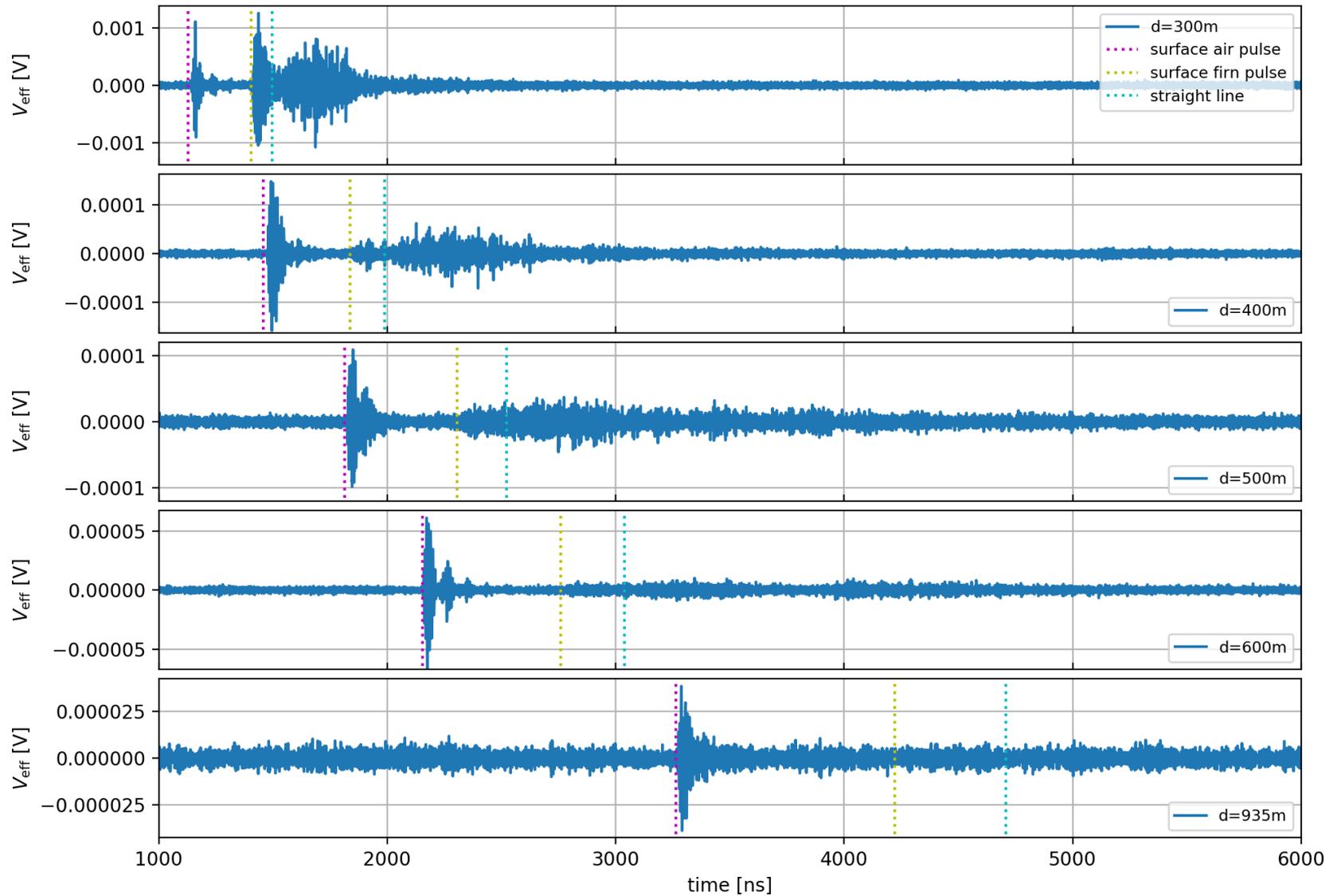




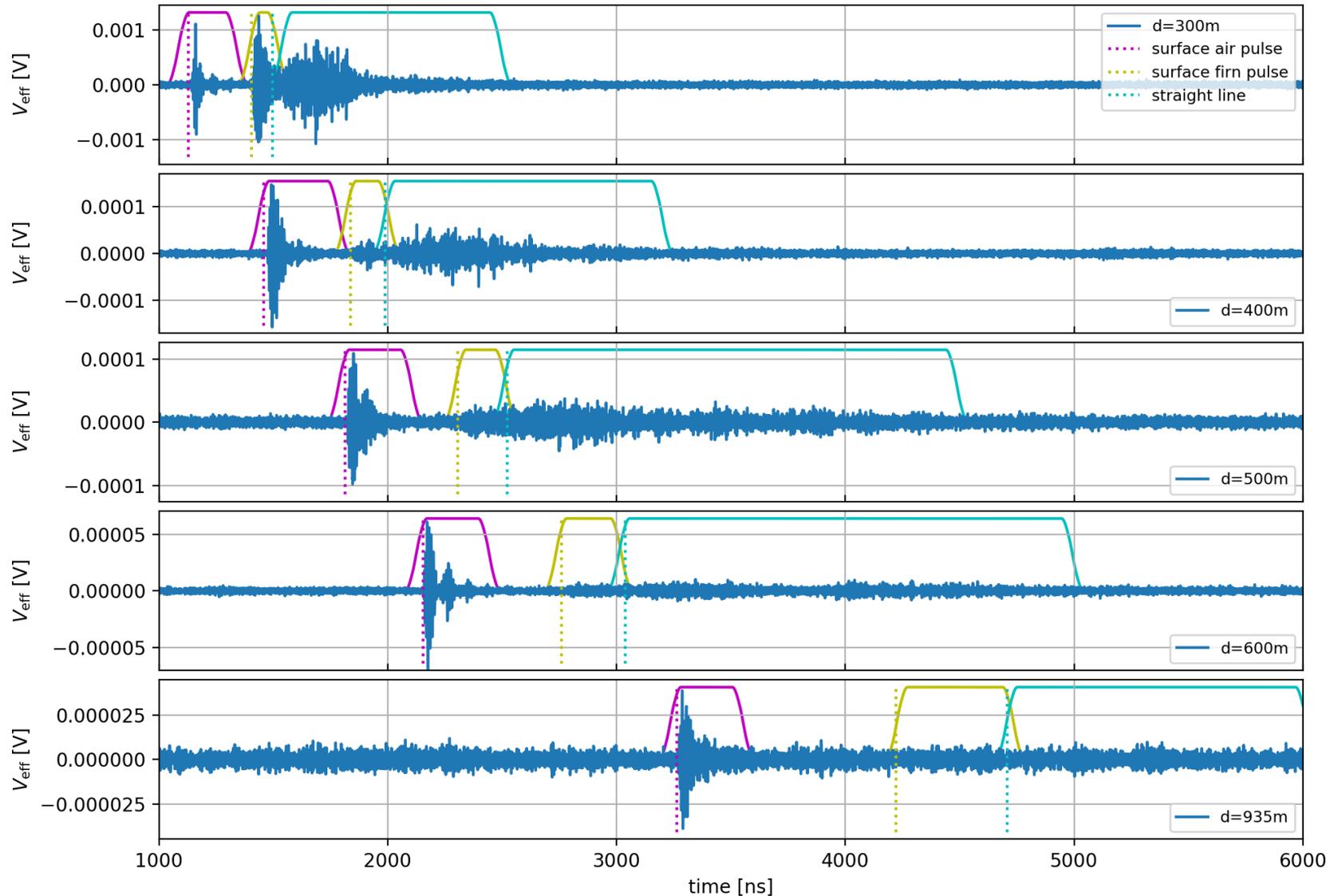
Define three ray paths for ‘horizontal propagation’:

- ‘surface air pulse’: ray reaching surface at critical angle, travelling in a straight line through the air, entering the firn at the critical angle such that it reaches the position of the receiver.
- ‘surface firn pulse’: As above, traveling in firn along surface
- ‘straight line pulse’: TOA consistent with  $\int n(z)c_0^{-1} ds$  along straight line

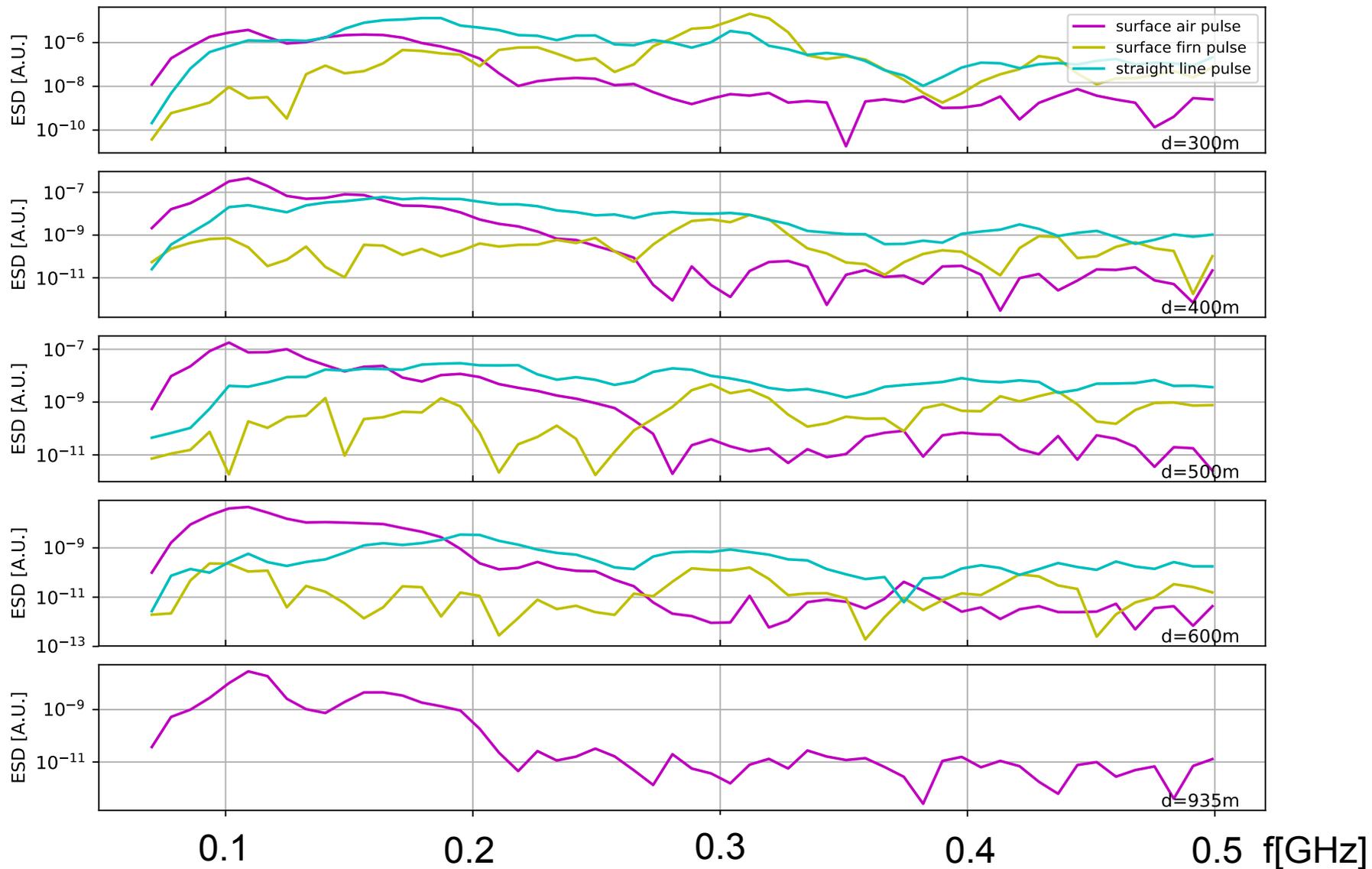
# Time Traces with Calculated Pulse Times



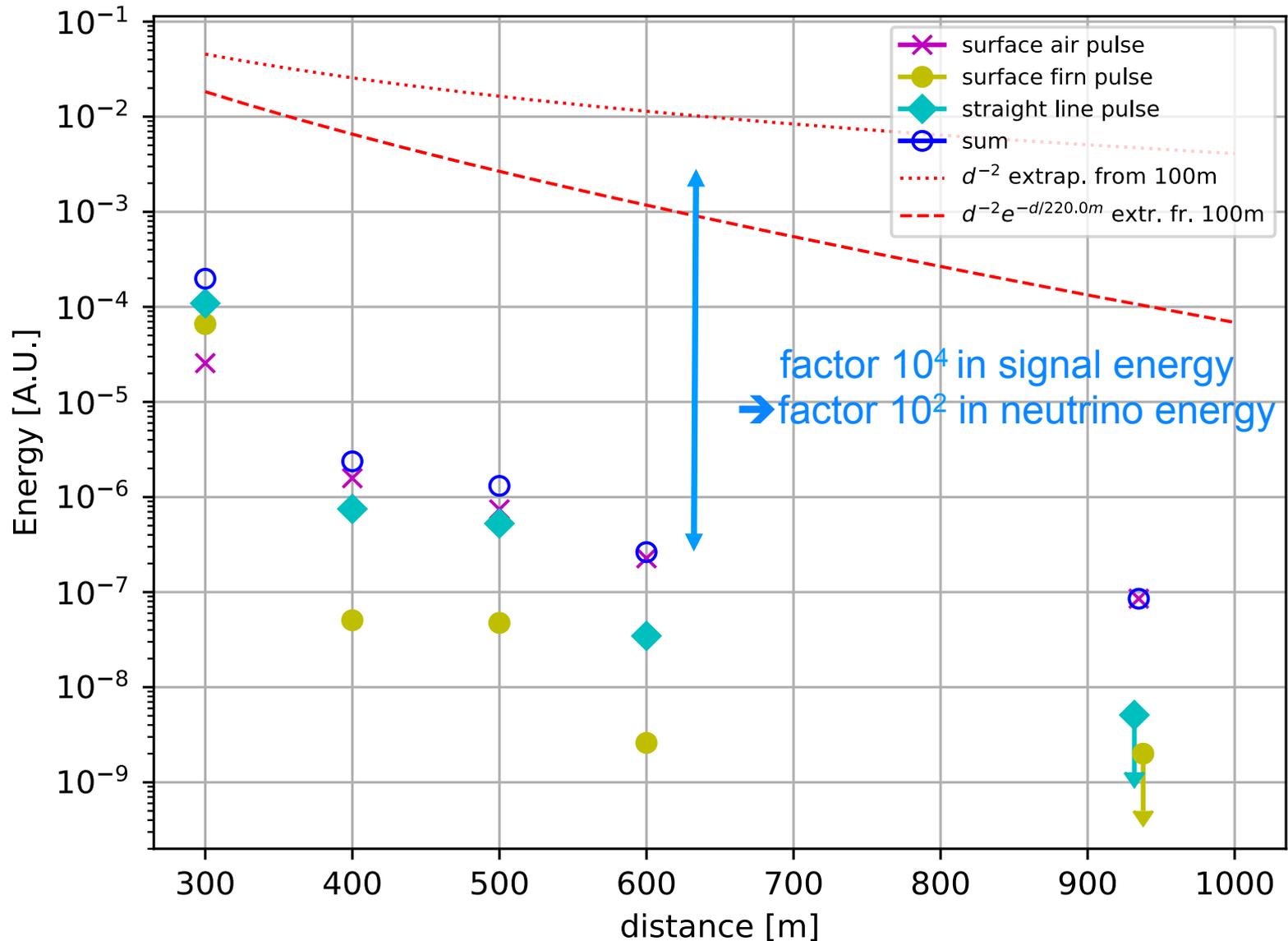
# Ranges for Energy and Spectrum Analysis



# Energy Spectral Density



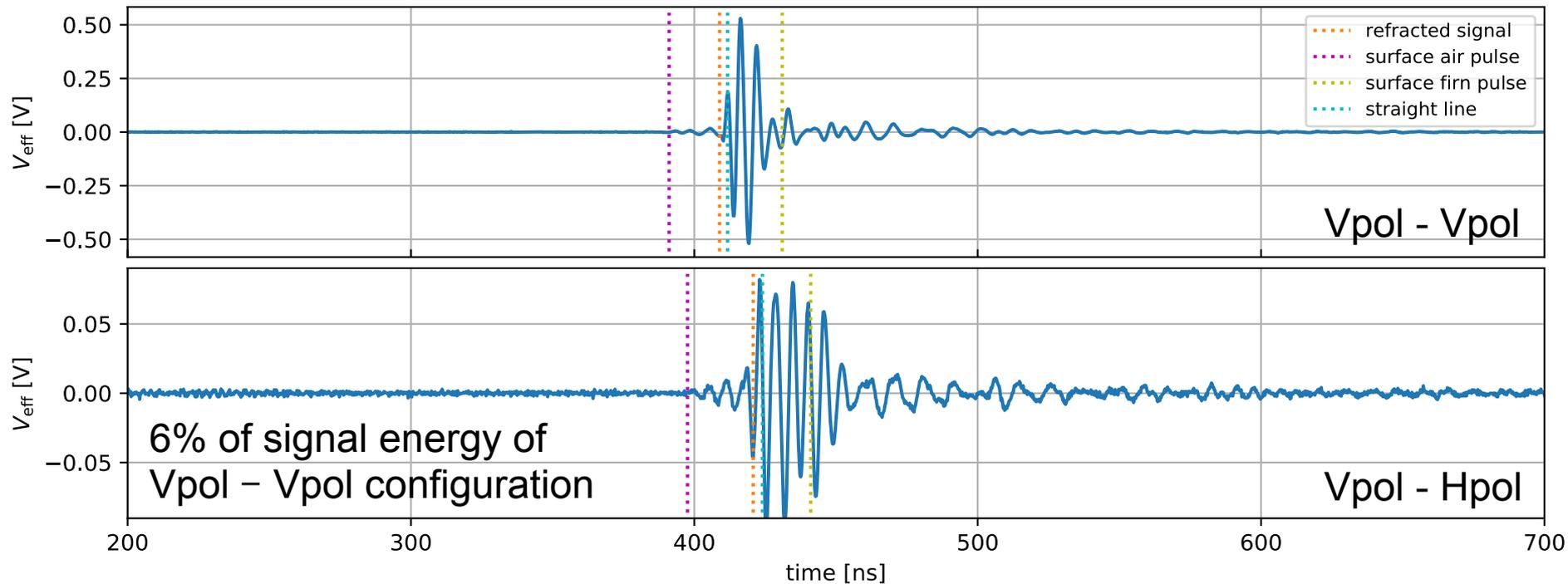
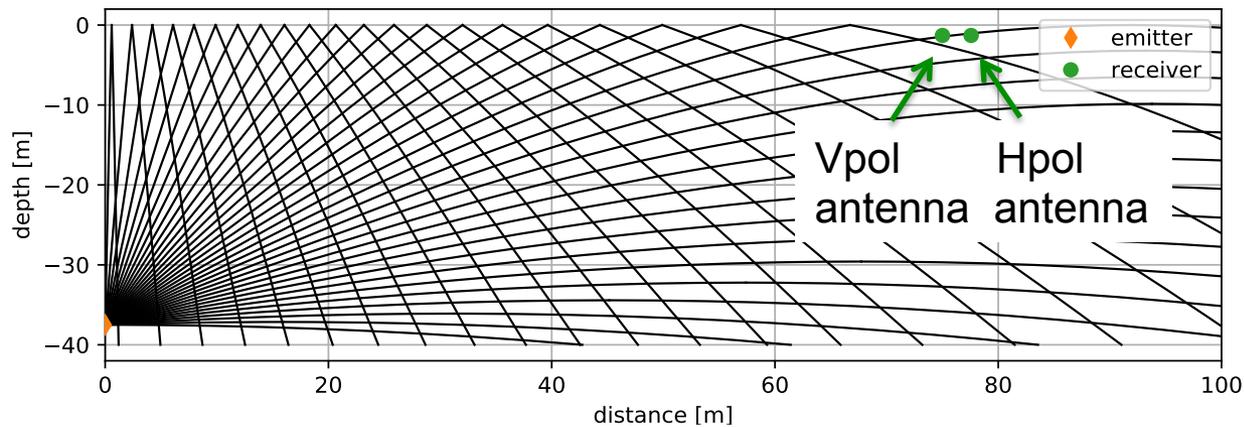
# Energy vs. Distance by Signal Types



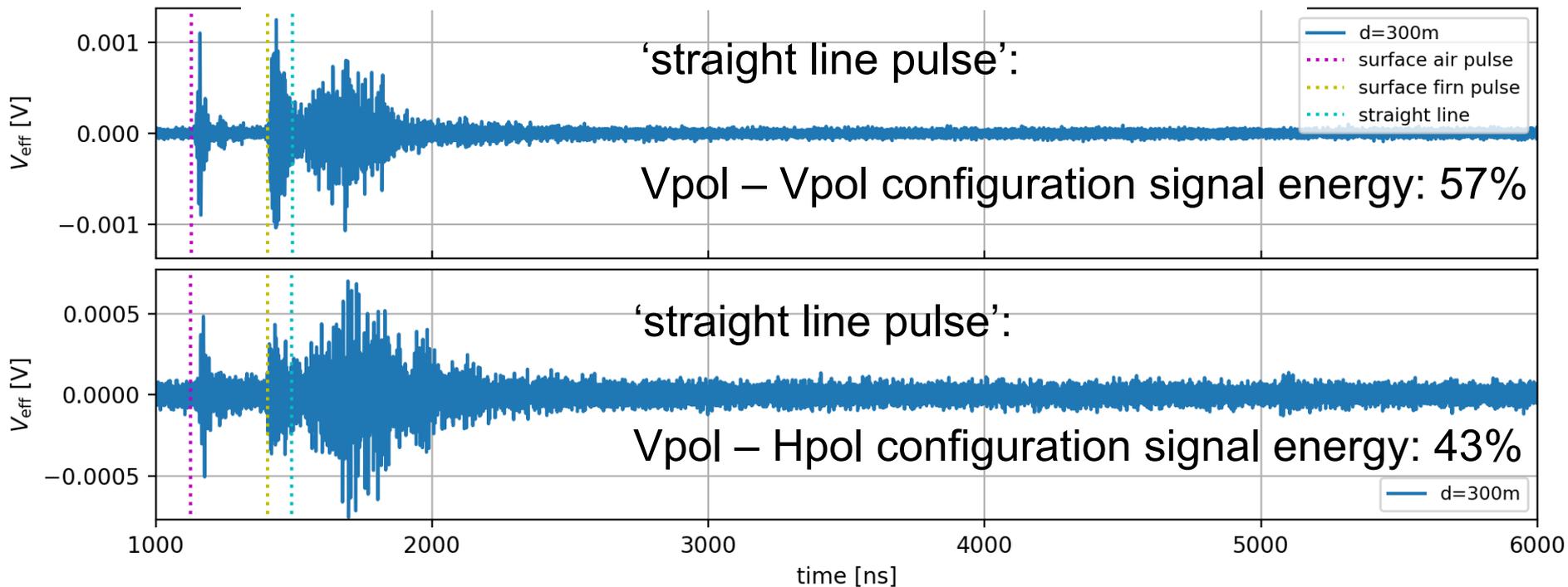
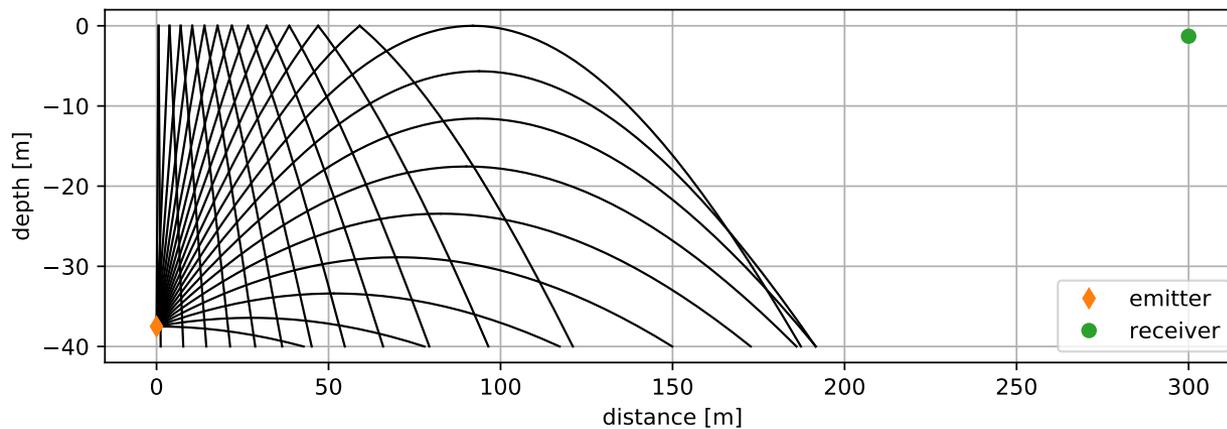


# Variation of Dipole Orientation

# Vpol Emitter at ~75m horizontal distance



# Receiver at 300m, Co- and X-pol Signal



- Three signal types with distinct time of arrival, frequency content, and attenuation length have been observed in the shadow zone at the ARIANNA site; arrival times well described phenomenologically
- Horizontal propagation could increase the effective volume for neutrinos with energies exceeding the trigger threshold for signals in the refraction zone by a factor of 30 ~ 100
- Polarisation information gets “randomised” at 300m distance for the ‘straight line signal’ in the shadow zone
- Further studies may lead to a genuine model of horizontal propagation that can be implemented into Monte Carlo simulations



**Backup slides**

# Shallow Hpol Emitter at ~75m distance

