# SnowScat,
# X- to Ku-Band Scatterometer Development

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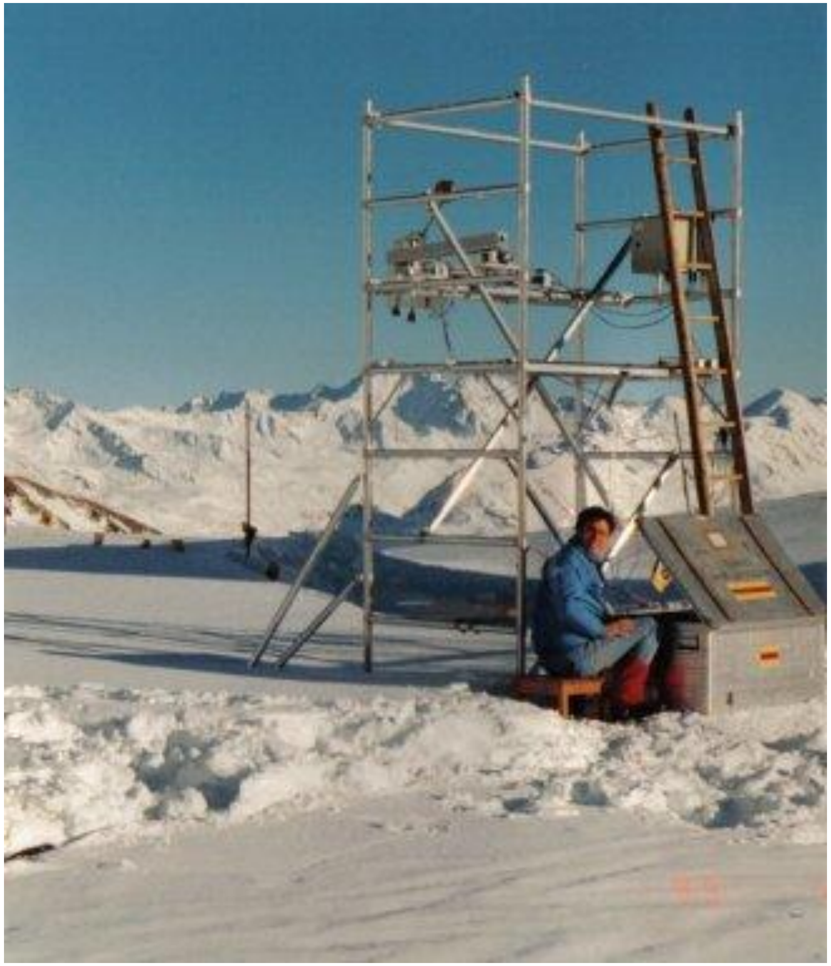
ESA Living Planet Symposium, Bergen
28.6. - 2.7. 2010

# Outline

- **Motivation**
- **Objectives**
- **Instrument Development**
- **Calibration Approach**
- **Campaign 2009**
- **Conclusions**

# Our Motivation



# SnowScat

## Objectives and Scope of the Call (from the SOW)

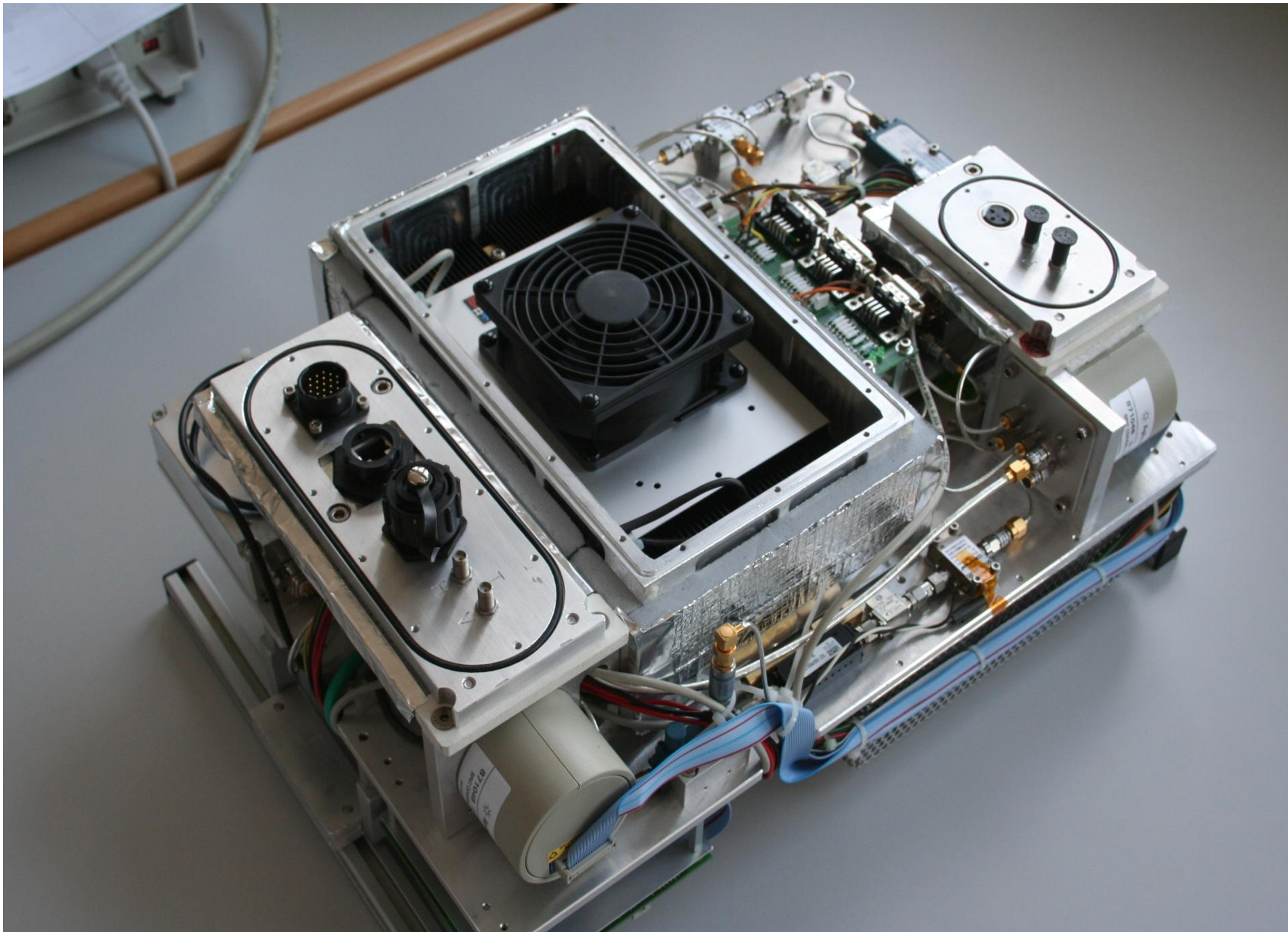
- to develop a simple, well calibrated, and transportable scatterometer at Ku-band for enabling ground-based campaigns over snow-covered areas
- to perform an initial field campaign for demonstrating its functionality and performance

# Instrument Development

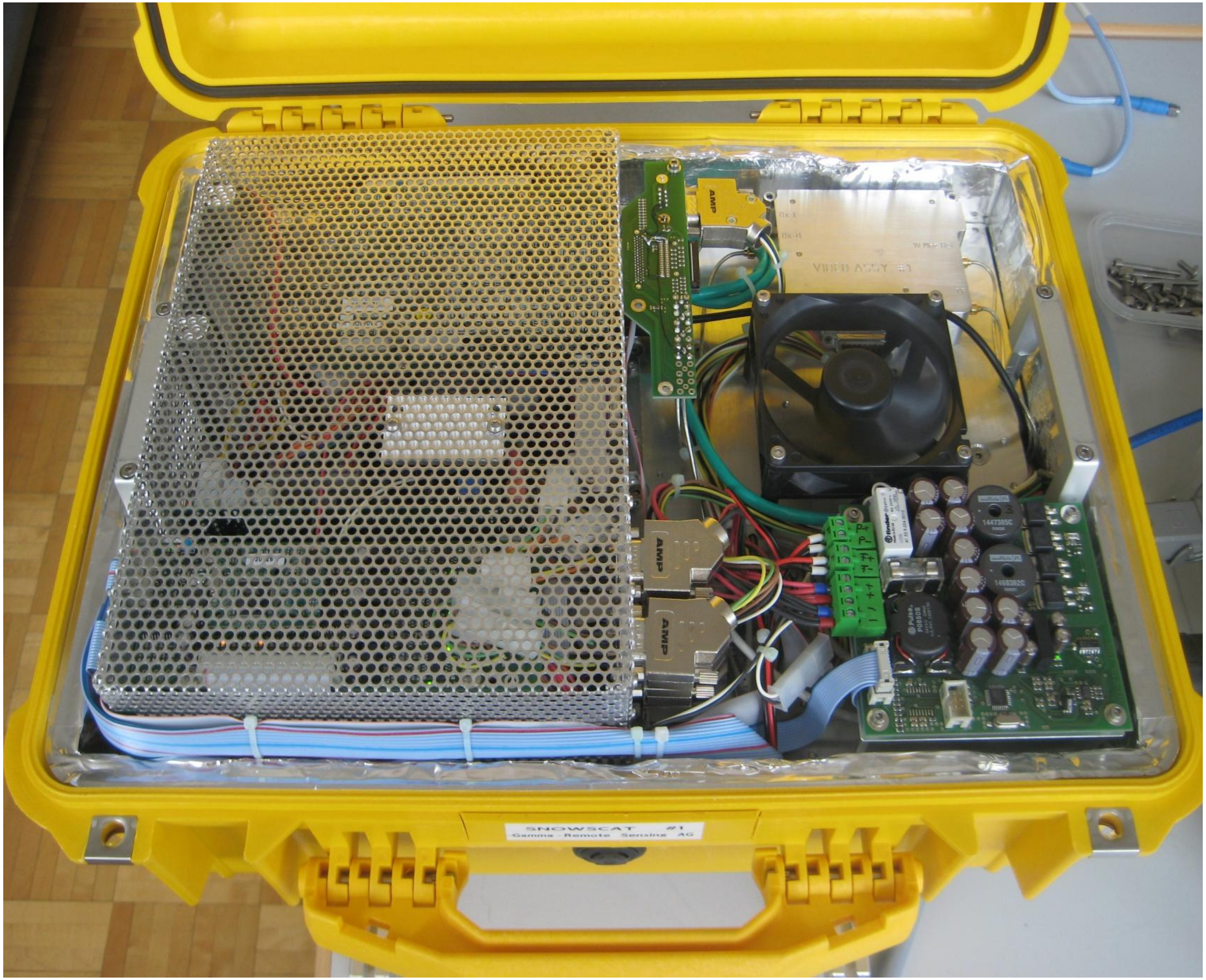
## Instrument short description

- Coherent stepped frequency FMCW scatterometer
- Covering 9 to 18 GHz
- VV, HH, HV, VH
- Internal and external calibration
- Can rotate in pan and tilt
- Can withstand cold and harsh environments
- Autonomous operation, remote access

# SnowScat Hardware RF Assembly

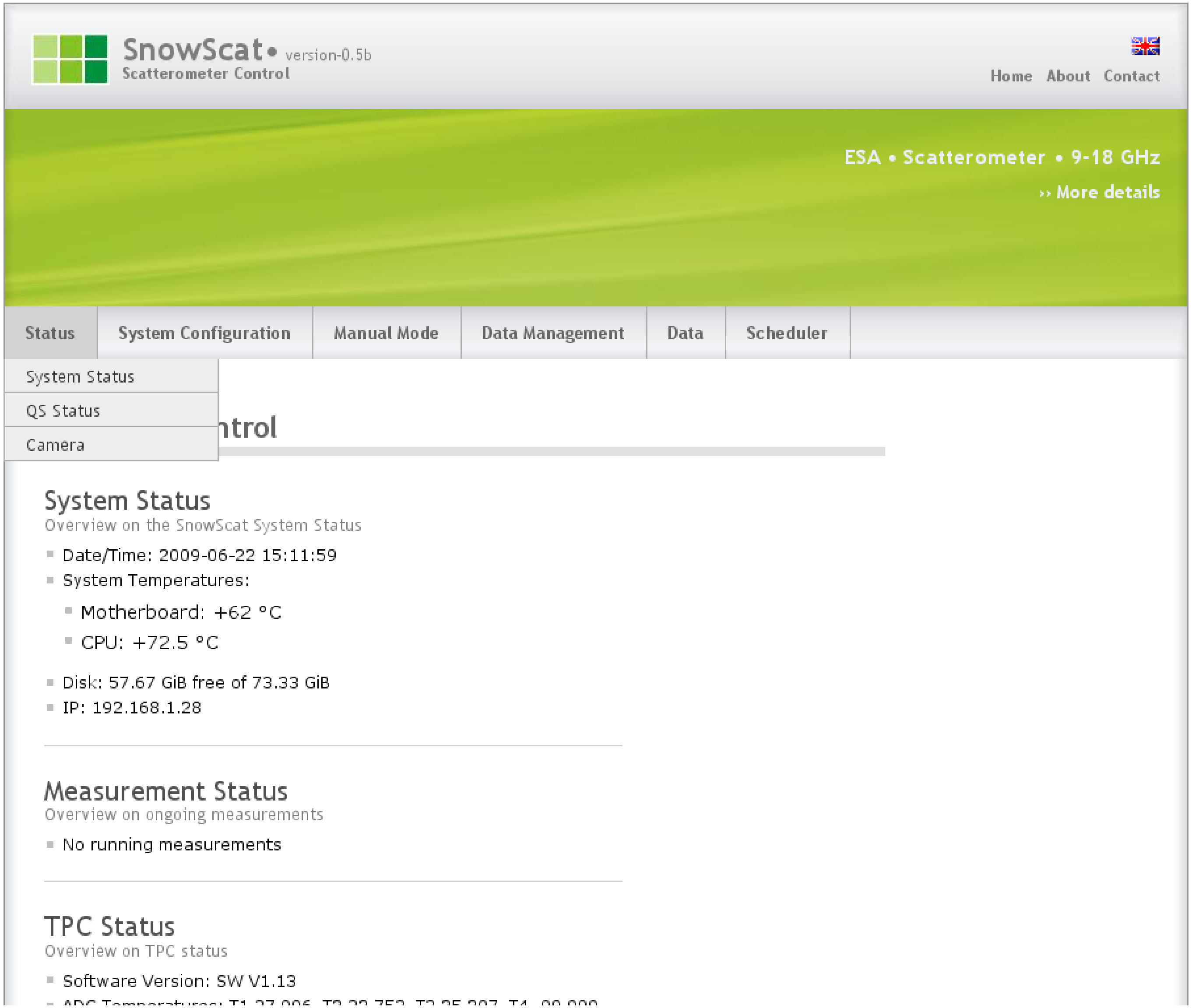


# SnowScat Hardware: Instrument Computer/Temperature Power Controller



# SnowScat Hardware: Power Distribution Unit with Handheld and WiFi Link: interior and deployed

# SnowScat Web based User Interface



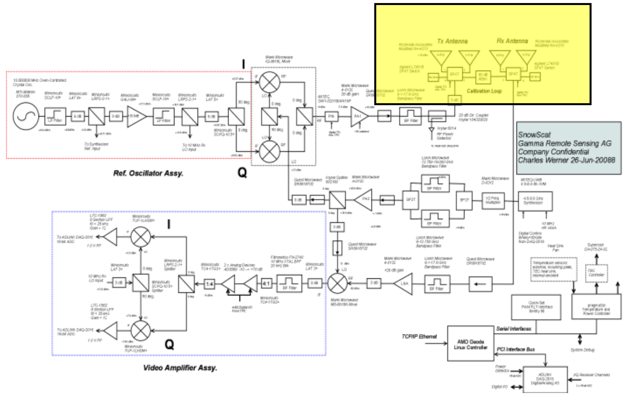
# SnowScat Specifications

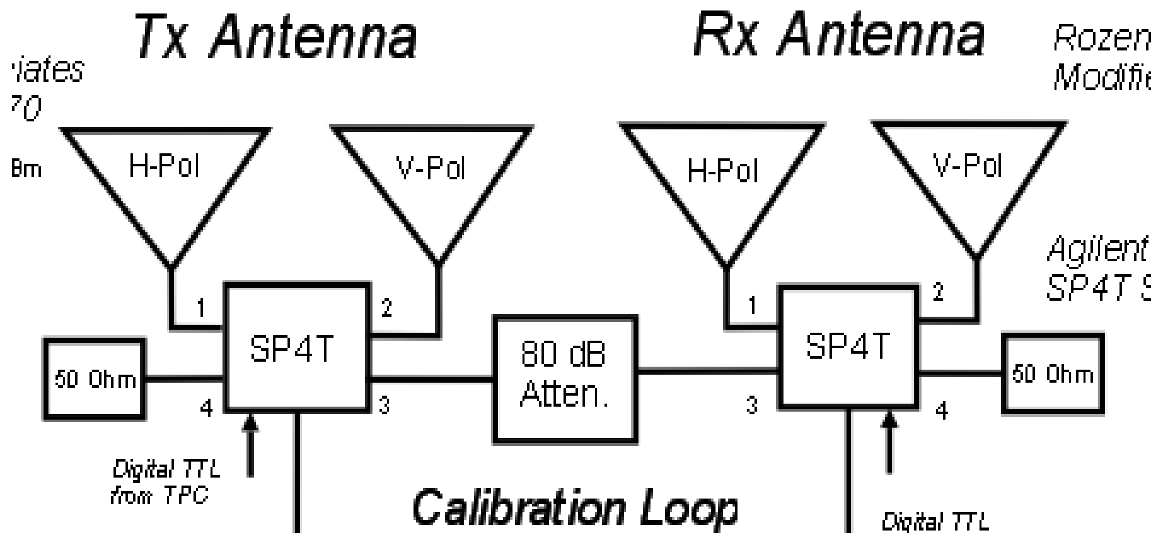
| | |
|---|---|
| Power: | 230V, max ~ 60W |
| Weight: | ~ 40 kg |
| Temperature Range: | -40° C to 40° C |
| Antenna: | dual pol, < 10° (3dB) |
| Antenna cross-pol. isolation: | < -20 dB |
| Frequency: | Stepped CW from 9.15 to 17.9 GHz |
| Incidence angle: | -40° to 110° |
| Azimuth angle: | -180° to 180° |
| Polarization: | HH, HV, VV, VH |
| Dynamic range: | Receiver dyn. range > 80 dB with the 16 bit ADC |
| Signal bias: | < 0.5 dB |
| Gain characterization: | Internal cal. loop, reference target (8" sphere) |
| Control: | Remote Control through Ethernet; stand alone |
| Data storage: | Internal, external through Ethernet |
| RFI: | Frequency blacklist |

# SnowScat Calibration

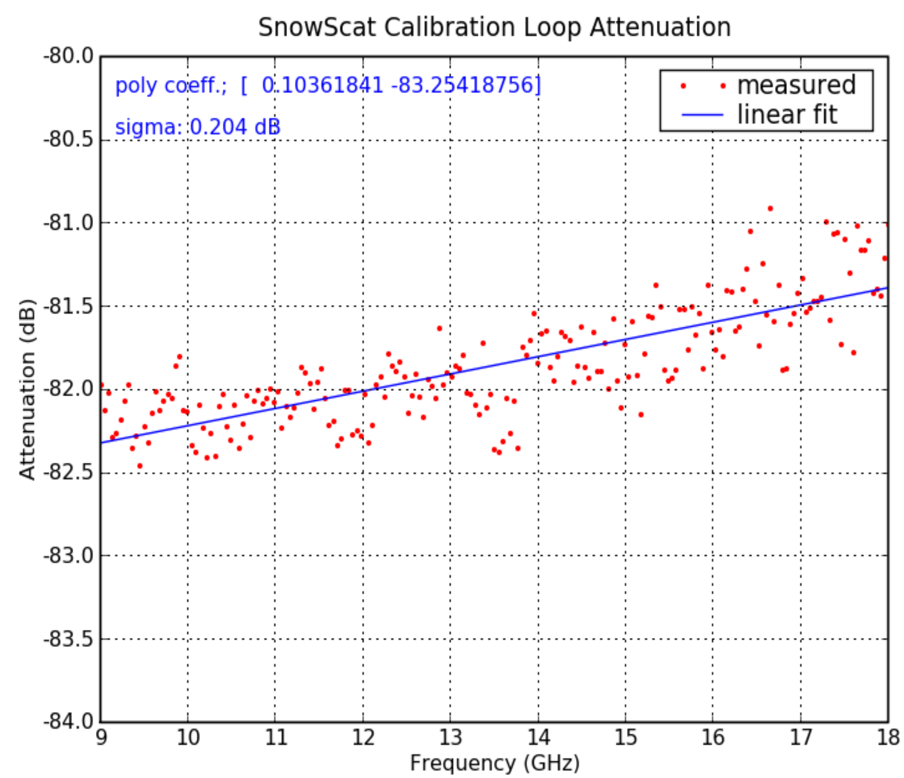
- Internal Calibration Loop measurements (usually done before each measurement)
- Antenna Diagram measured at ESTEC CATR (one time measurement)
- Calibration target (sphere) measurement (once per campaign for system characterisation, and repeated before and after each measurement cycle to have an independent measure of end-to-end system performance)

# Calibration loop




- $P_t$ = CC / Attenuation



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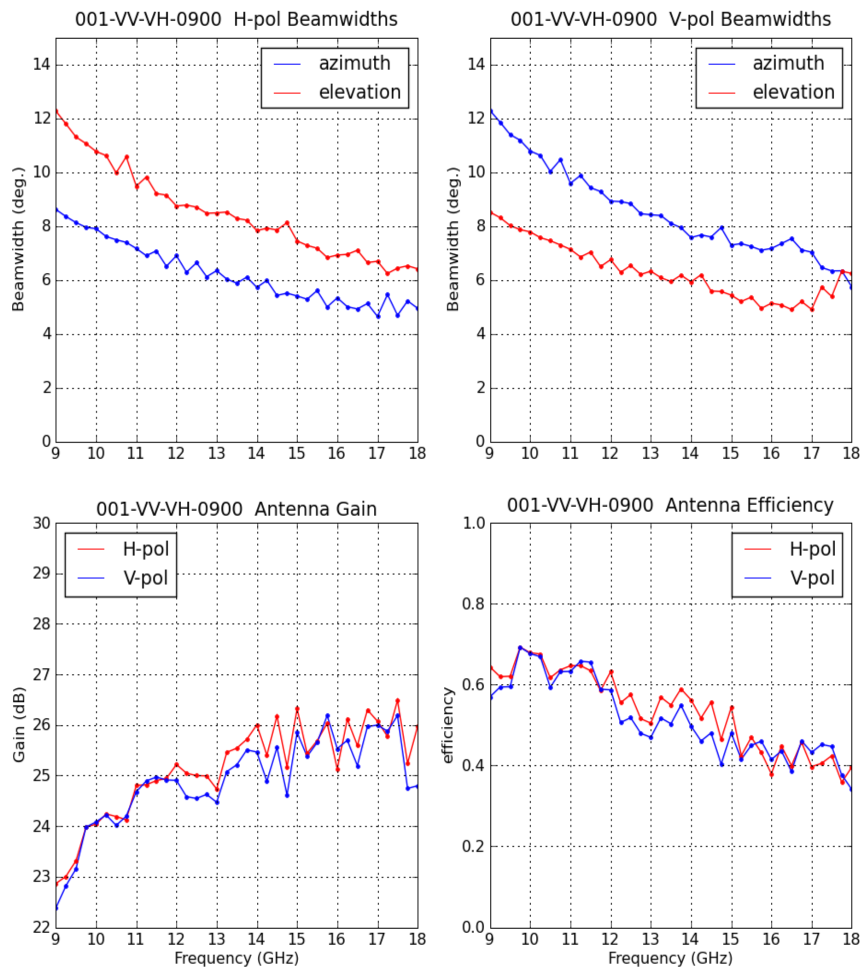
# Antenna Pattern Measurements

## Remeasured in ESTEC CATR with higher spectral resolution in August 2010.

Beamwidth

Gain

Efficiency



# Sphere (radius = 10.16 cm, distance = 24.5 m)

# Calibration Target Measurements in Field

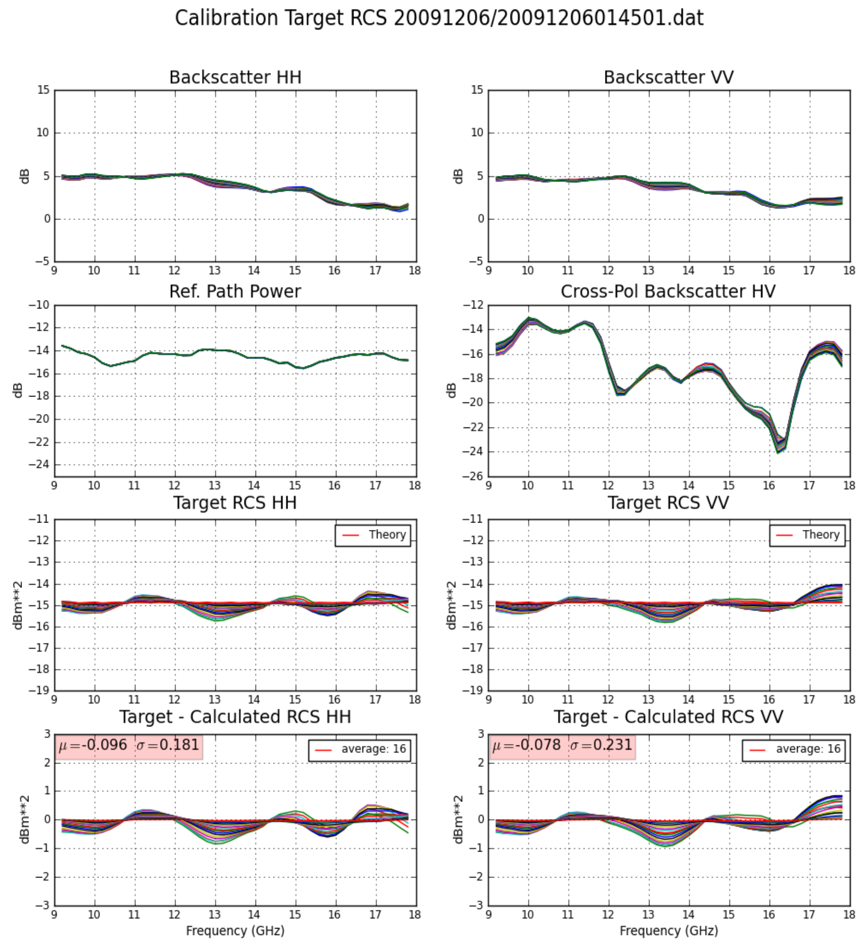
Once per campaign and repeated for performance monitoring before and after each cycle.

Backscatter HH

Calibration Loop

RCS sphere HH

RCS – deviation from theory: HH




Backscatter VV

Backscatter HV

RCS sphere VV

RCS – deviation from theory: VV



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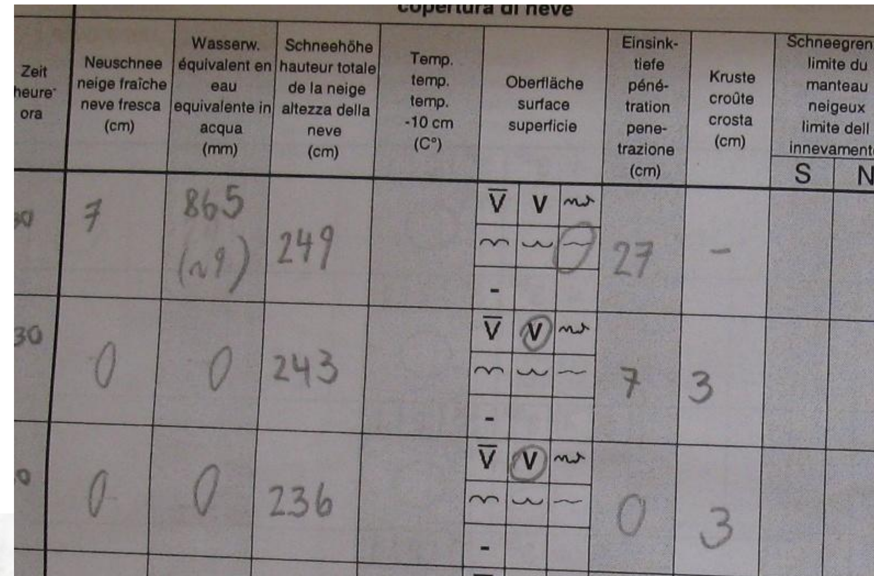
# Test Campaign Feb-Apr 2009 in Davos

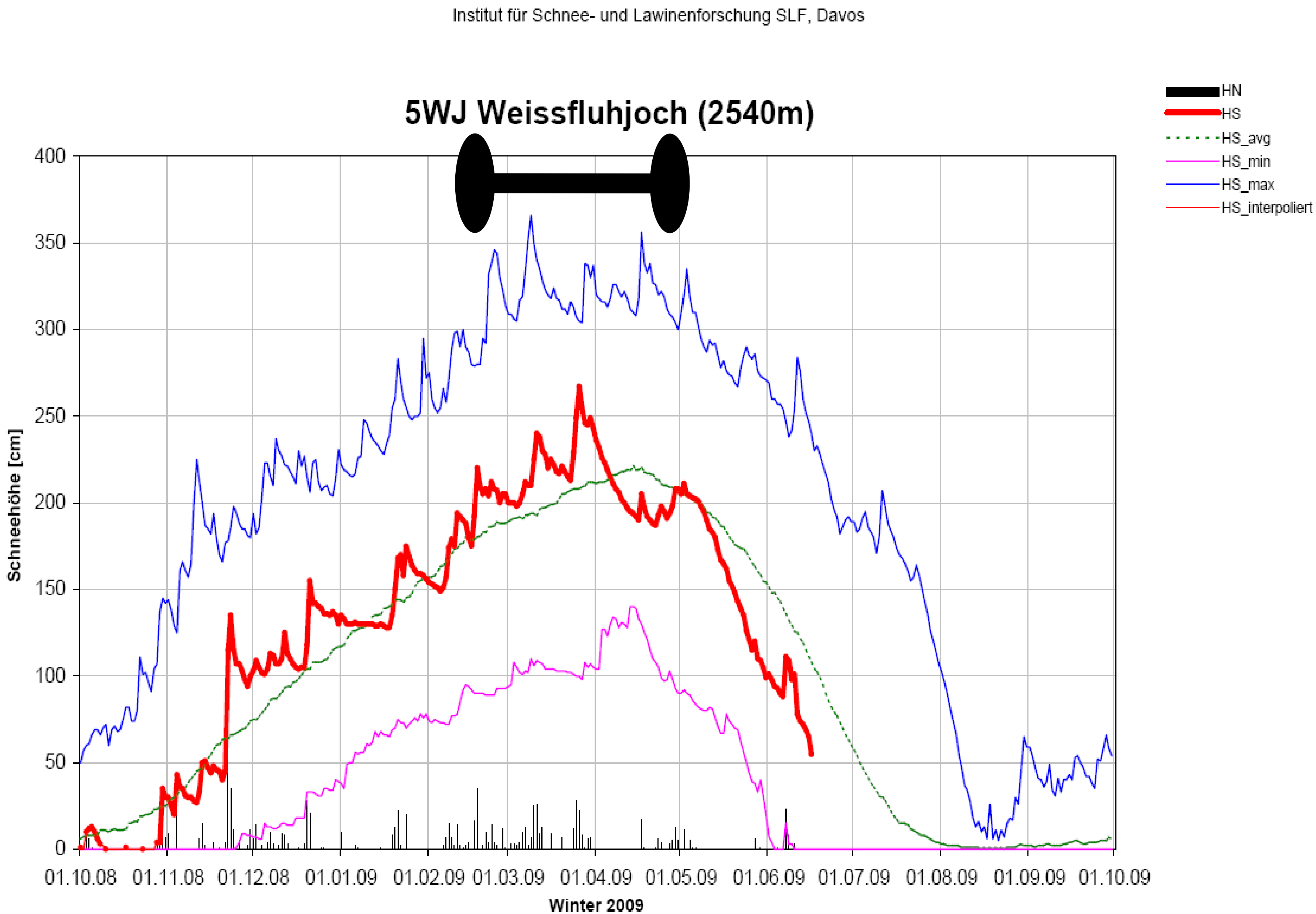

# Campaign Aux. Measurements



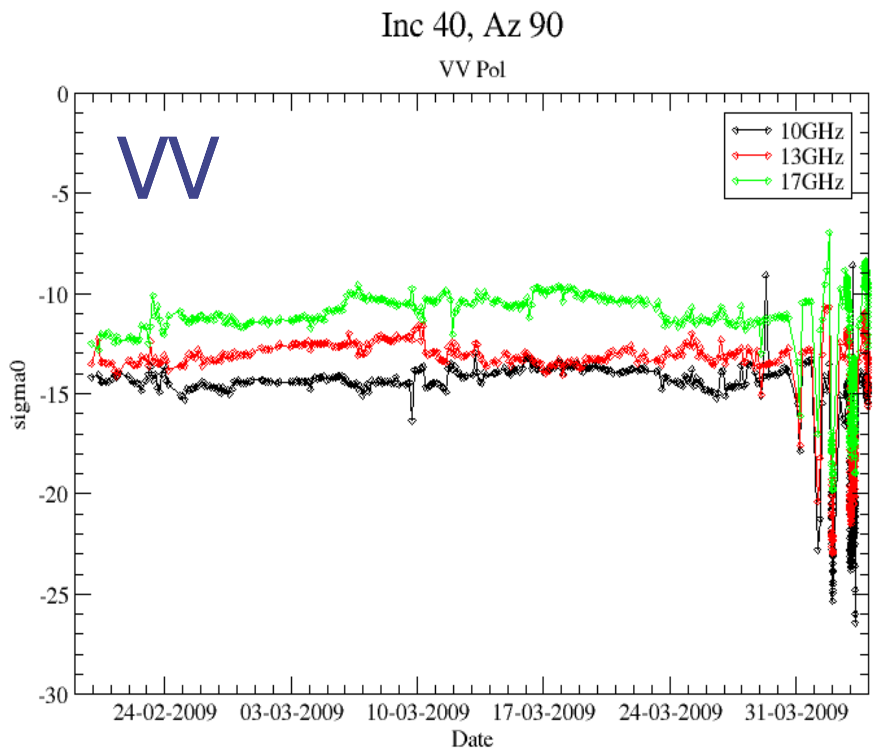
copertura di neve

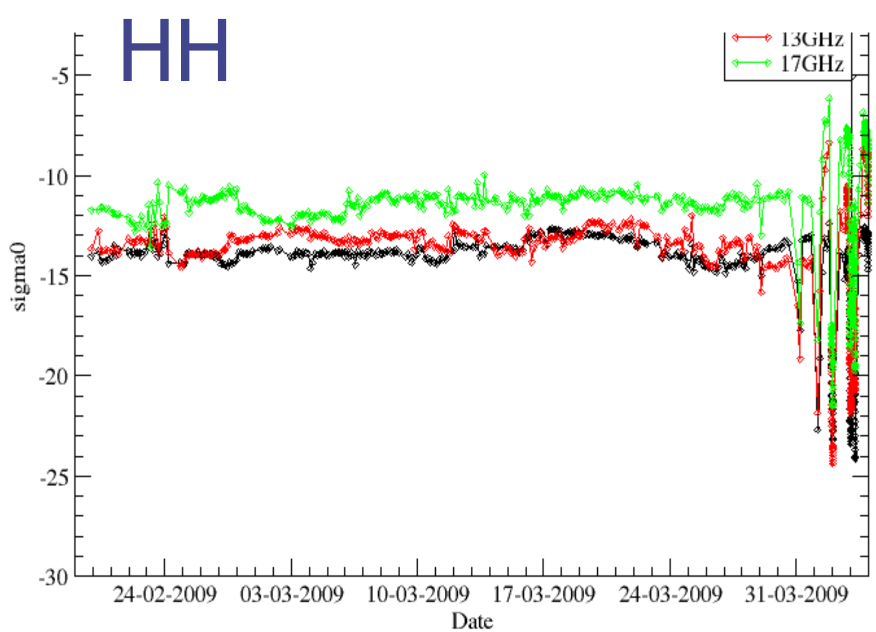
| Zeit heure ora | Neuschnee neige fraîche neve fresca (cm) | Wasserw. équivalent en eau equivalente in acqua (mm) | Schneehöhe hauteur totale de la neige altezza della neve (cm) | Temp. temp. temp. -10 cm (C°) | Oberfläche surface superficie | Einsink-tiefe péné-tration pene-trazione (cm) | Kruste croûte crosta (cm) | Schneegrenze limite du manteau neigeux limite dell innevamento S | N |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 7 | 865 (~9) | 249 | | | 27 | – | | |
| 30 | 0 | 0 | 243 | | | 7 | 3 | | |
| 0 | 0 | 0 | 236 | | | 0 | 3 | | |

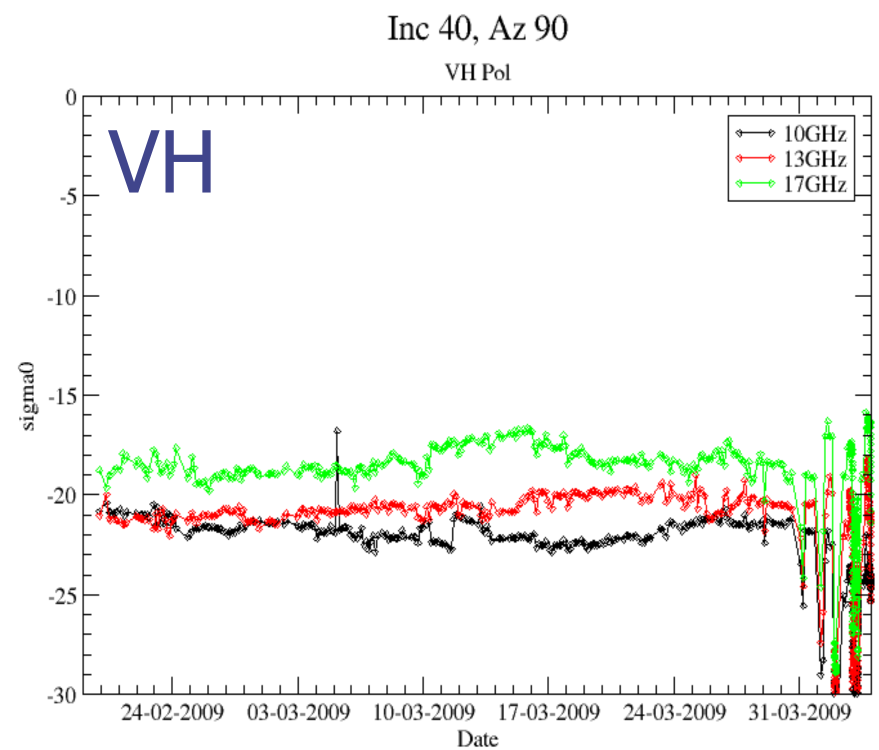
# Snowpack history in Davos



# Temporal behavior in Davos 40deg Incidence Angle

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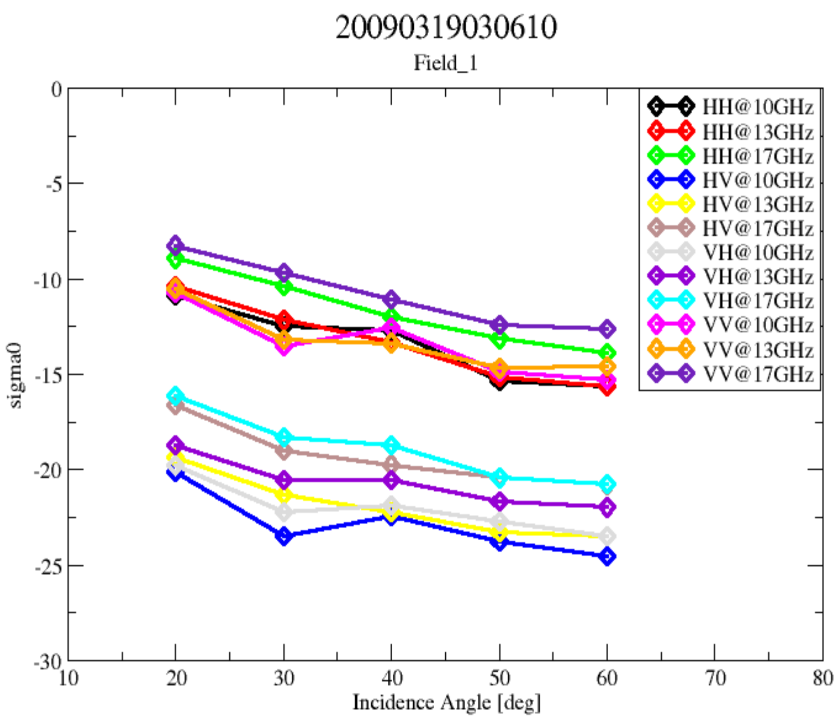
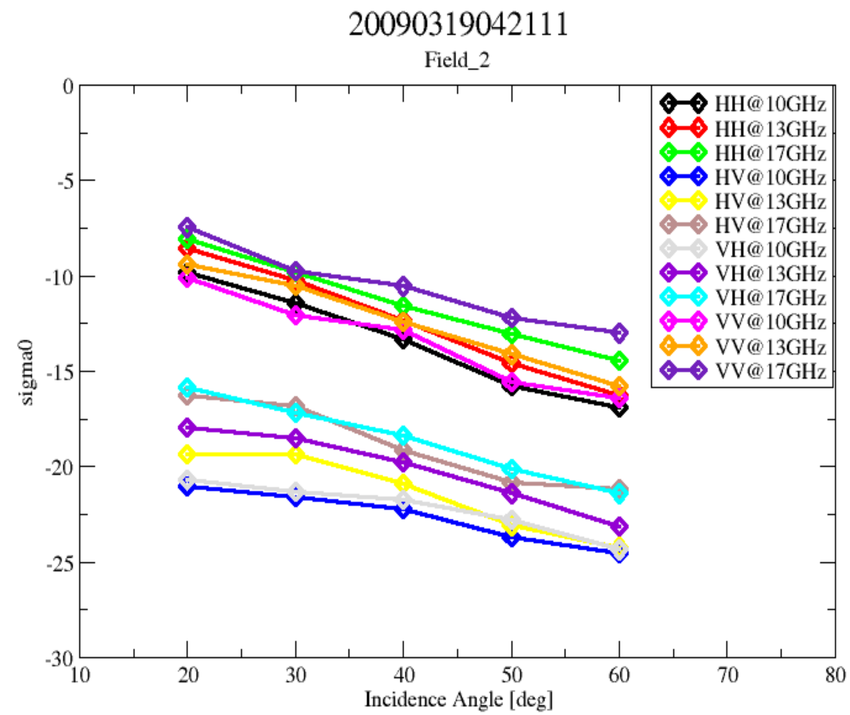
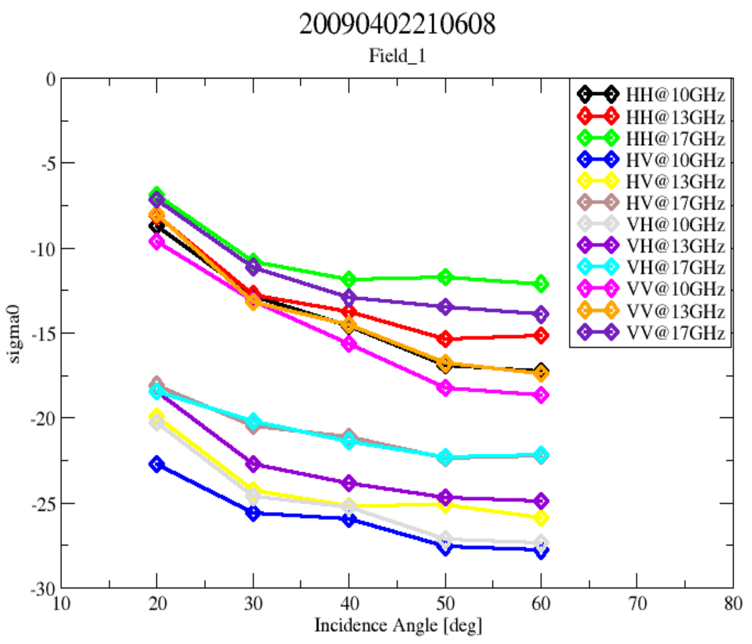
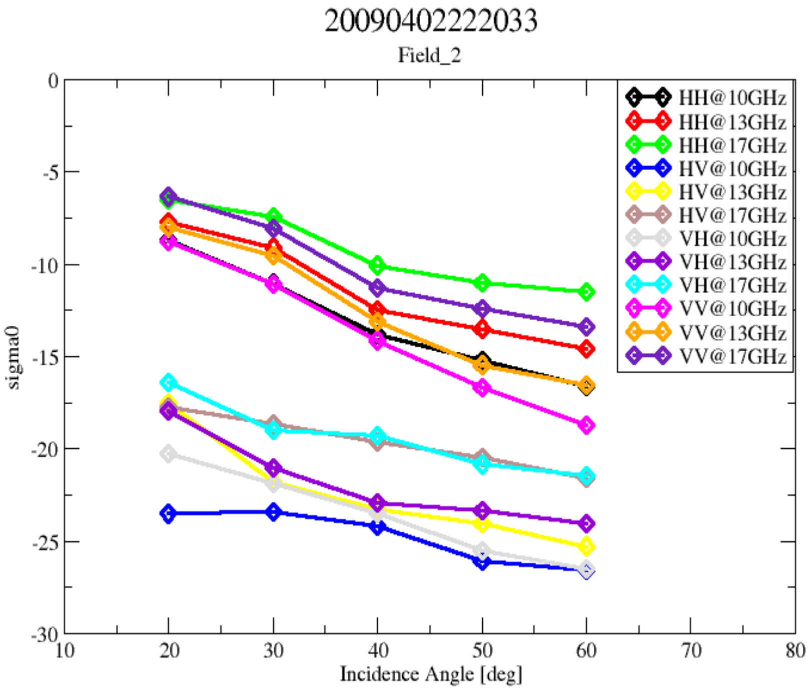
# Signatures in Davos (dry)



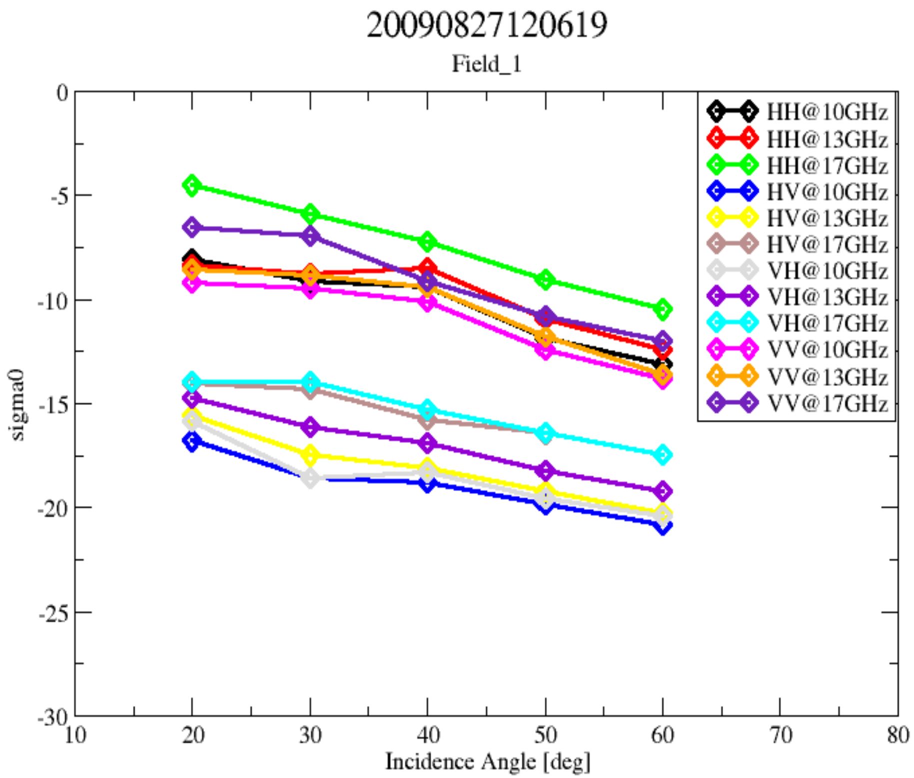



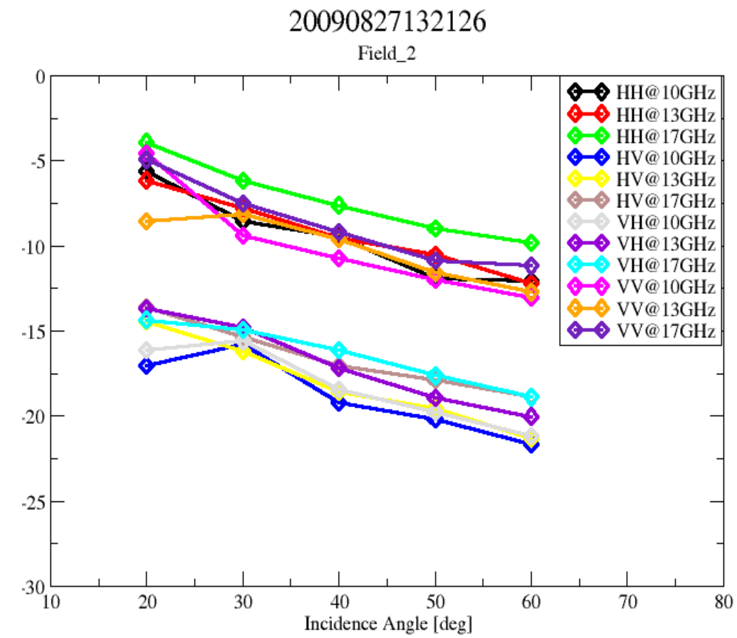
# Signatures in Davos (Refrozen)



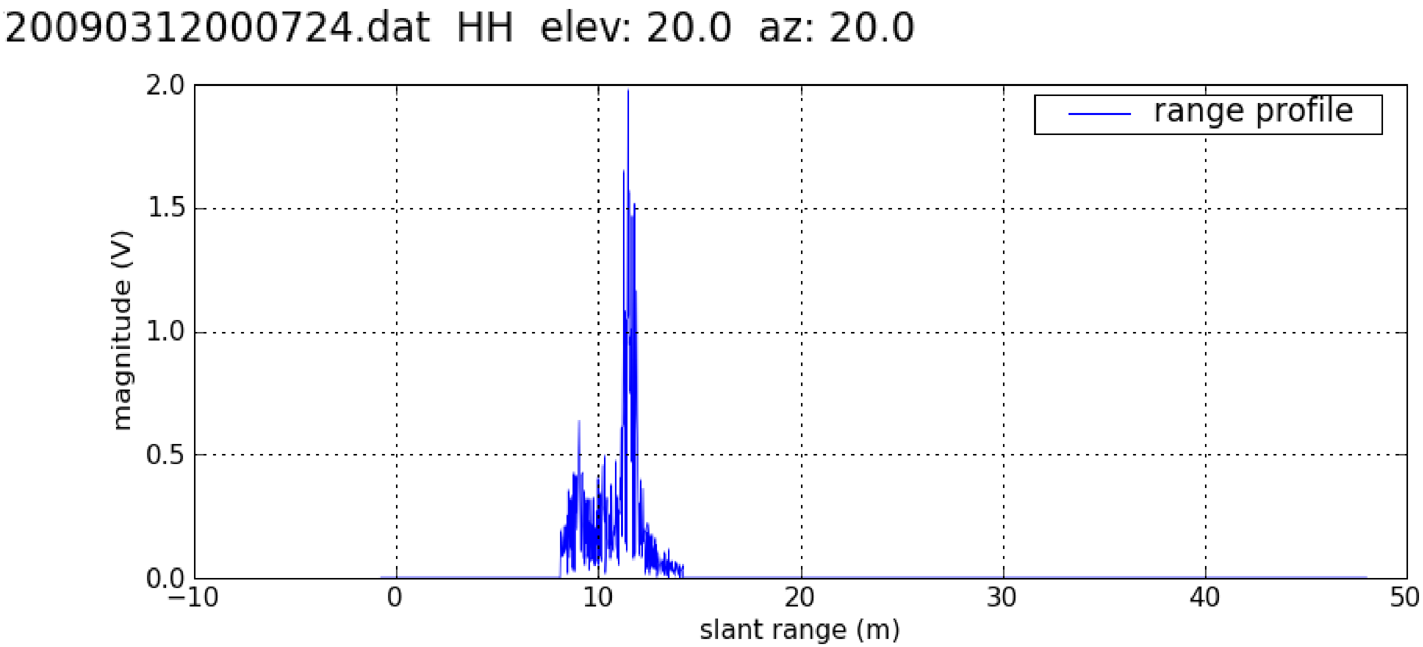



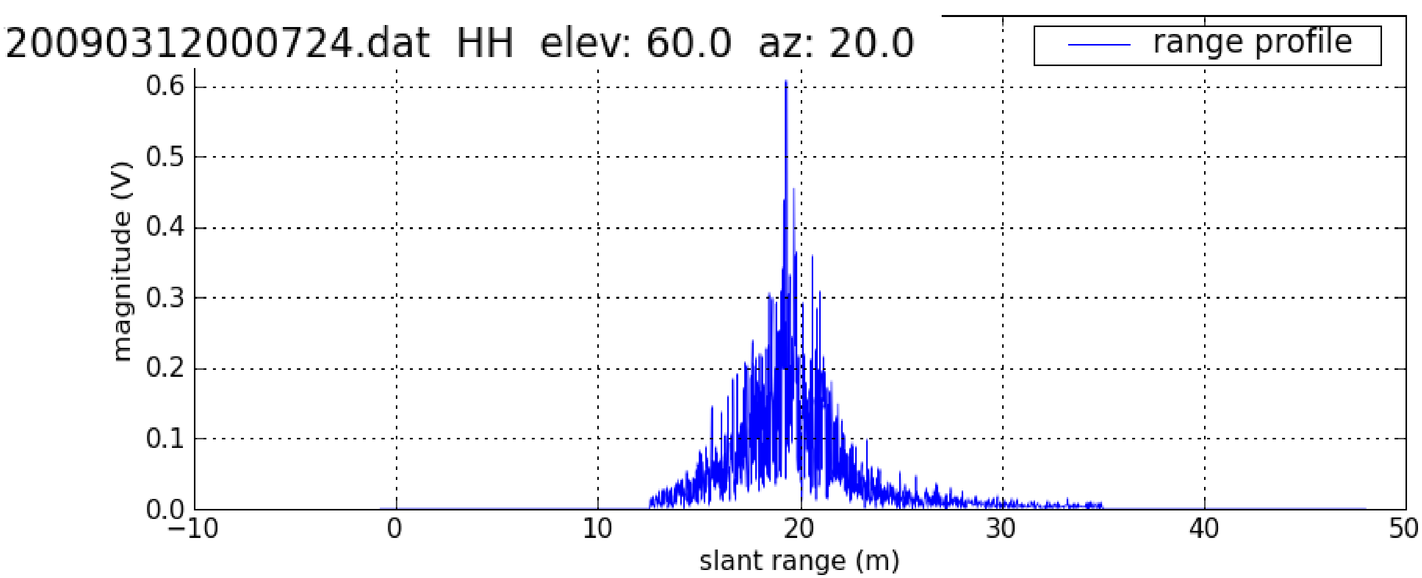
# Signatures in Davos (summer)



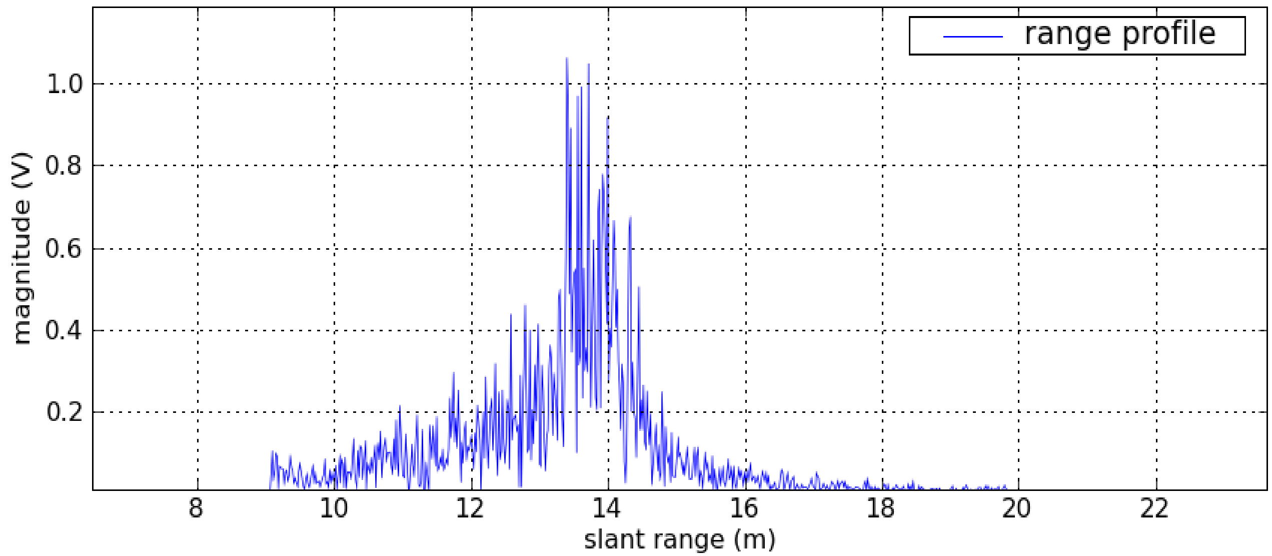



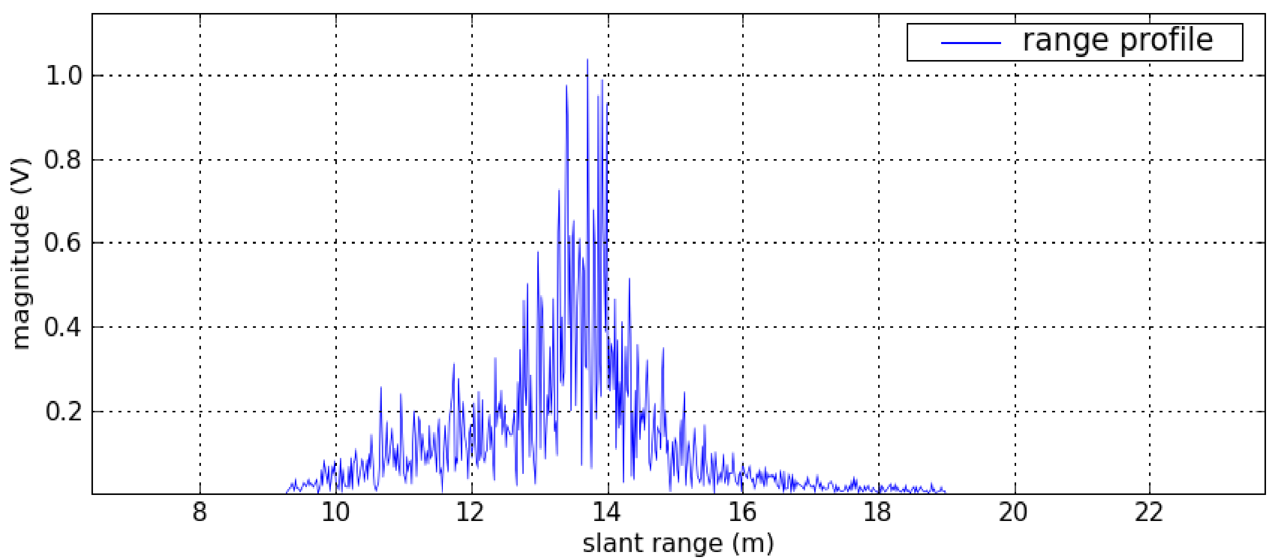
# Dry snowcover range profiles 20deg and 60deg Inc.



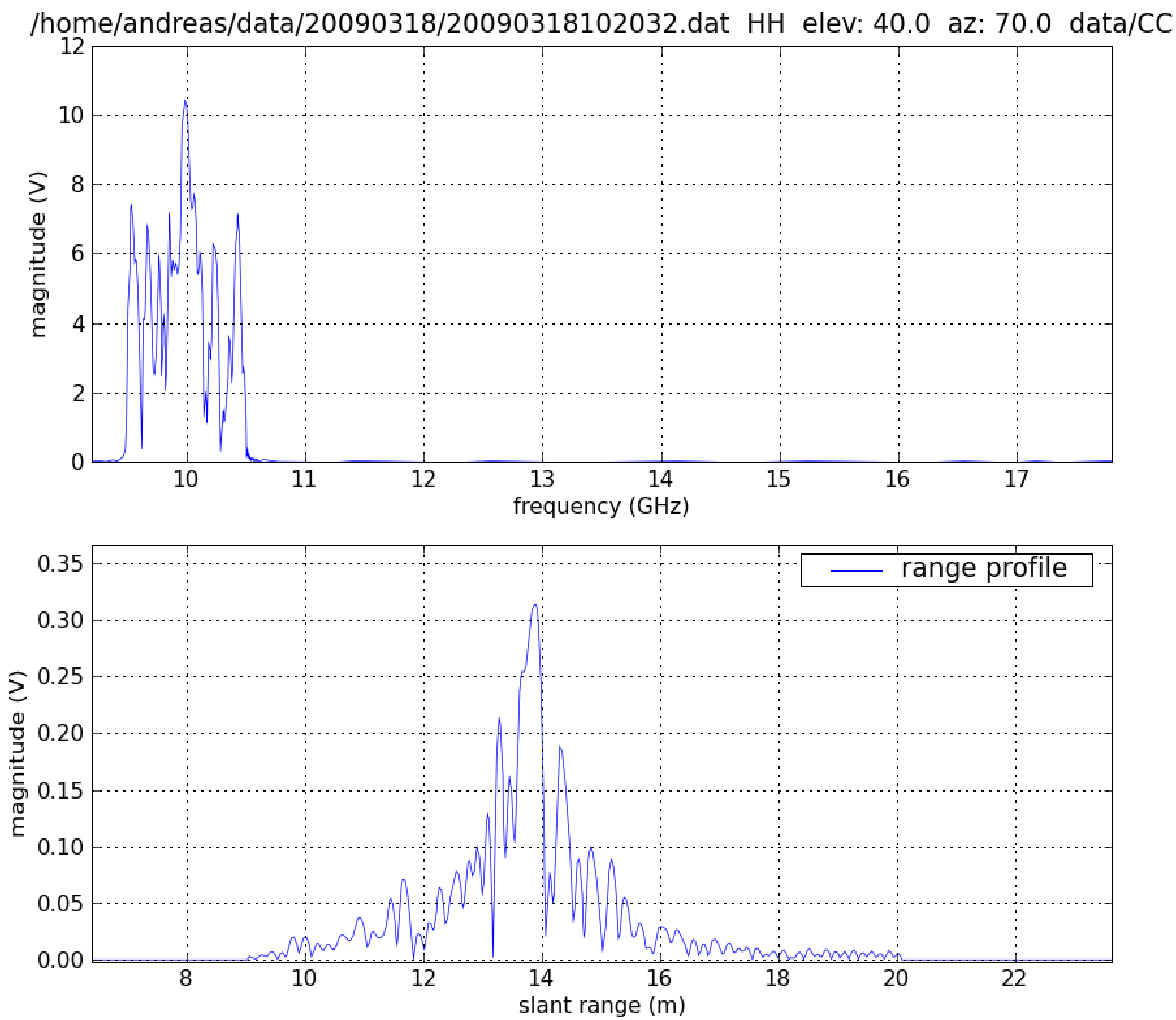



# Dry snowcover range profiles VV and HH 40deg Inc.



# Dry snowcover range profiles (X-band)

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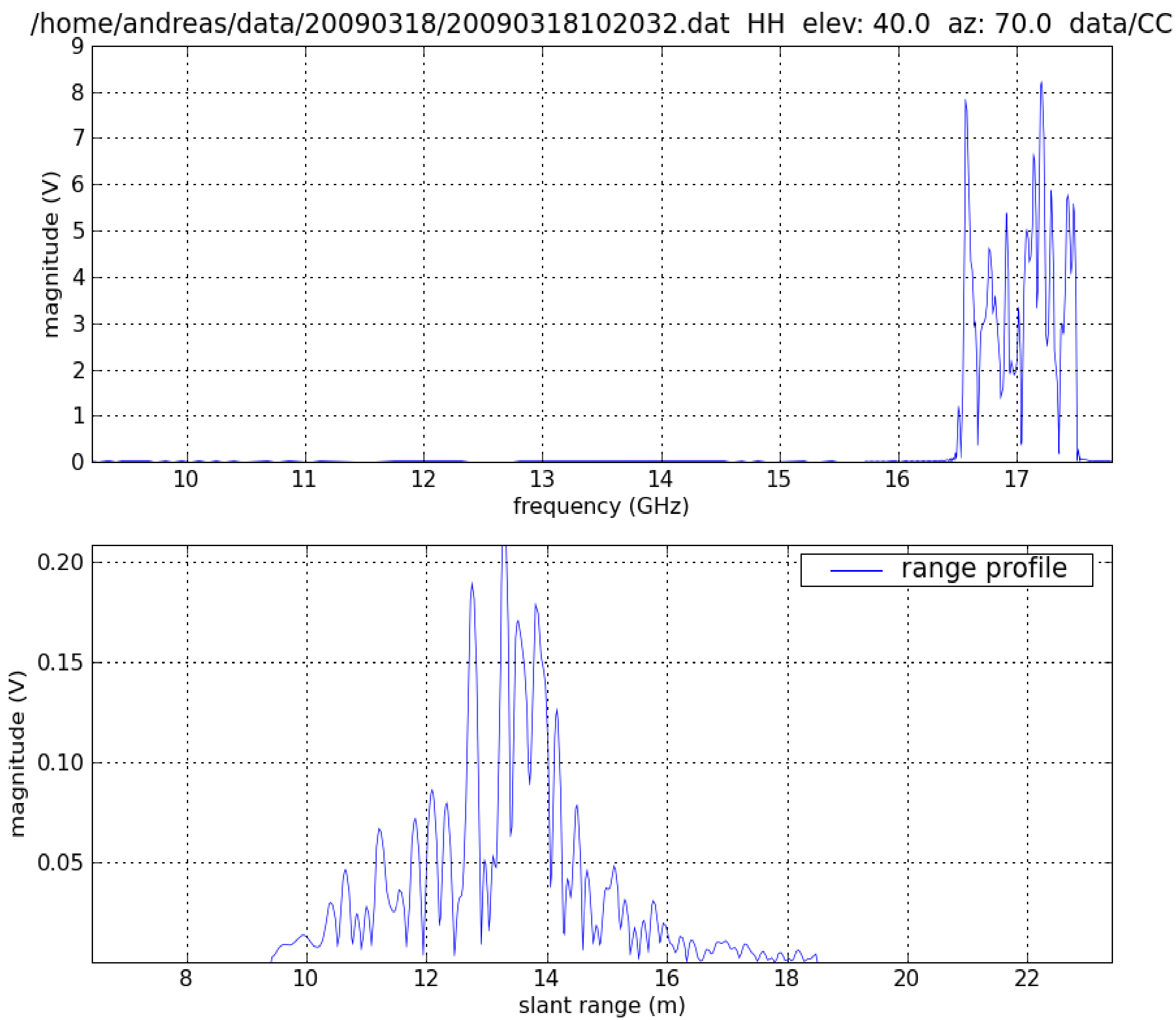
# Dry snowcover range profiles (Ku-band)

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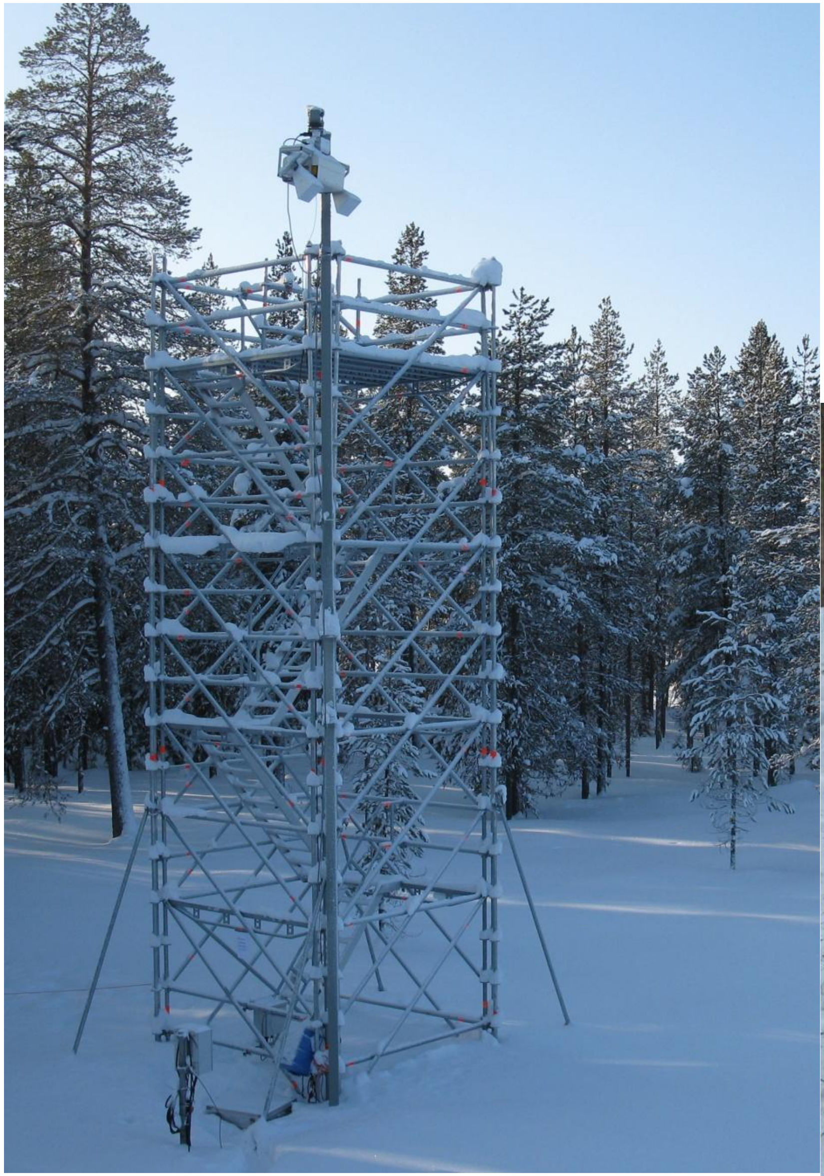
# Conclusions

- SnowScat instrument was built fulfilling the requirements and covering the full spectra from 9 to 18 GHz
- The calibration approach is based on internal and external calibration and performance control
- The campaign in the Swiss Alps proved instrument robustness and performance
- Snow Signatures were as expected, higher sensitivity at Ku-band and cross-pol. for new snow accumulation
- Scatter profiles are helpful to investigate the scatter mechanisms and the results support the CoReH20 dual frequency approach

# 2009/2010 NOSREX campaign in Sodankylä



Multi Sensor Campaign led by FMI, in collaboration with Enveo, Gamma and SLF