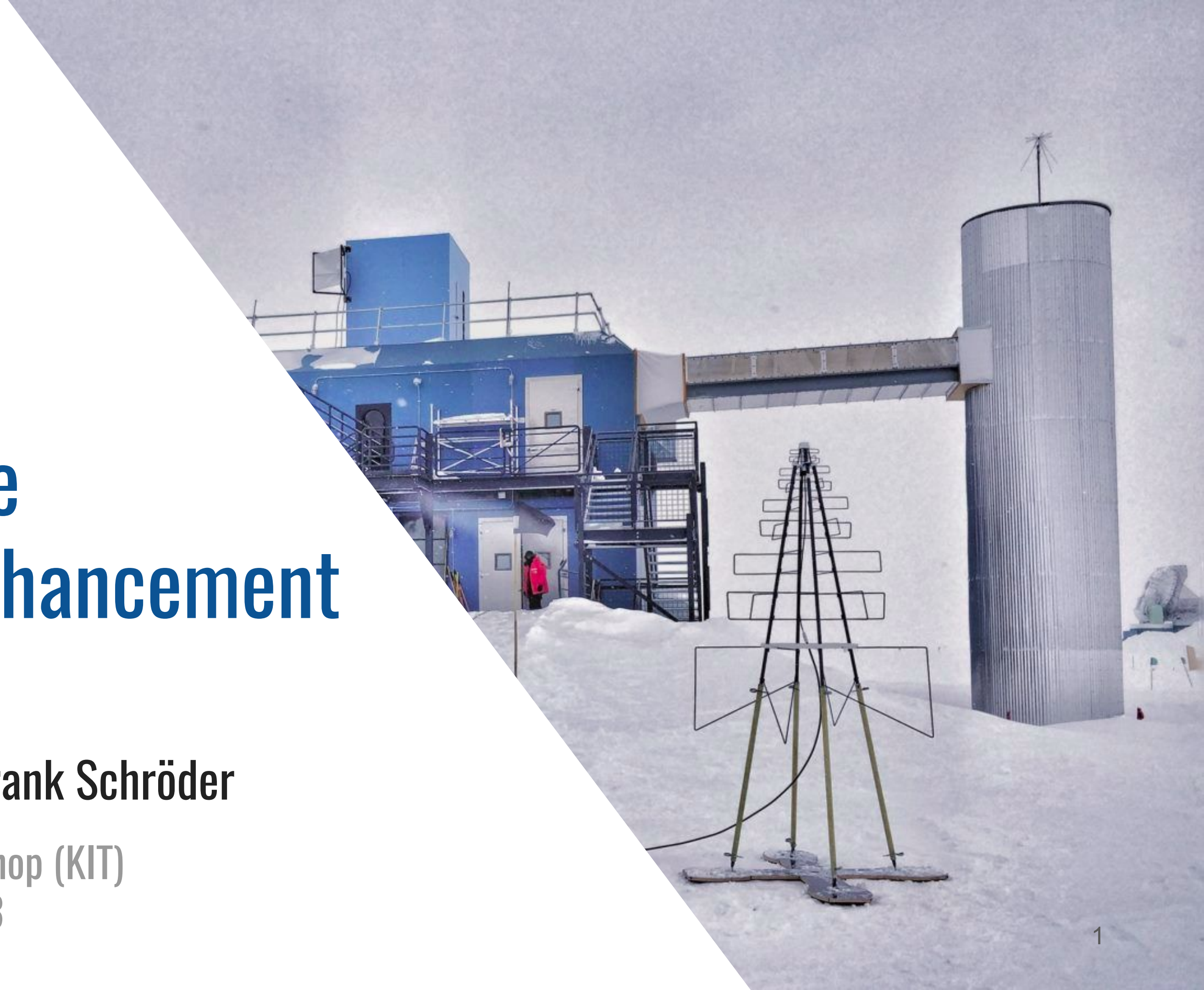
The use of CORSIKA for the IceTop Radio Enhancement



Alan Coleman and Frank Schröder

CORSIKA Workshop (KIT)
19.05.03

Overview

1. Previous/Current usage of simulations in IceTop
2. Usage for the IceTop enhancement
3. Planned usage of simulations in the future
4. Wishlist and outlook

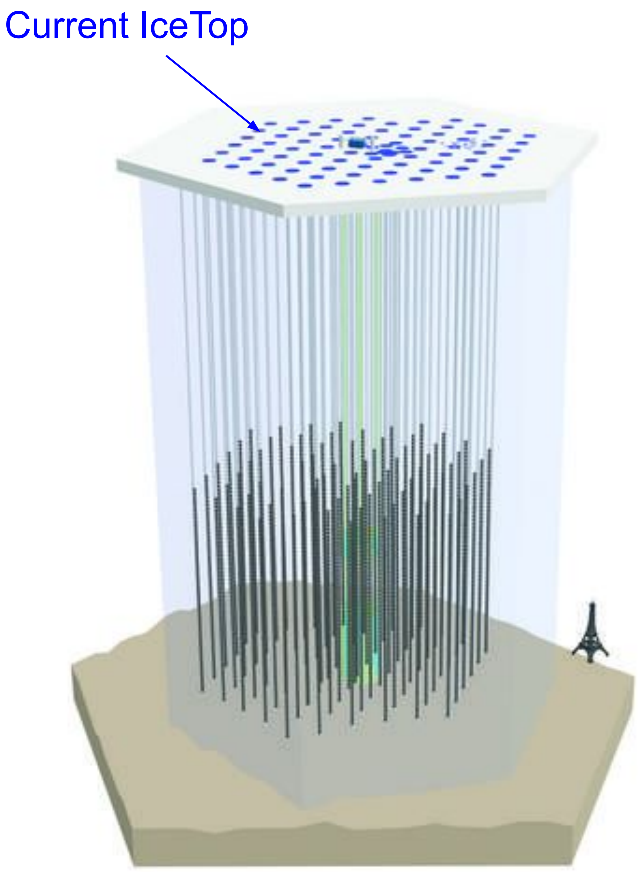
Previous/Current Usage of CORSIKA for IceTop

IceTop consists of 162 Cherenkov detectors above IceCube

Energy scale set via simulations

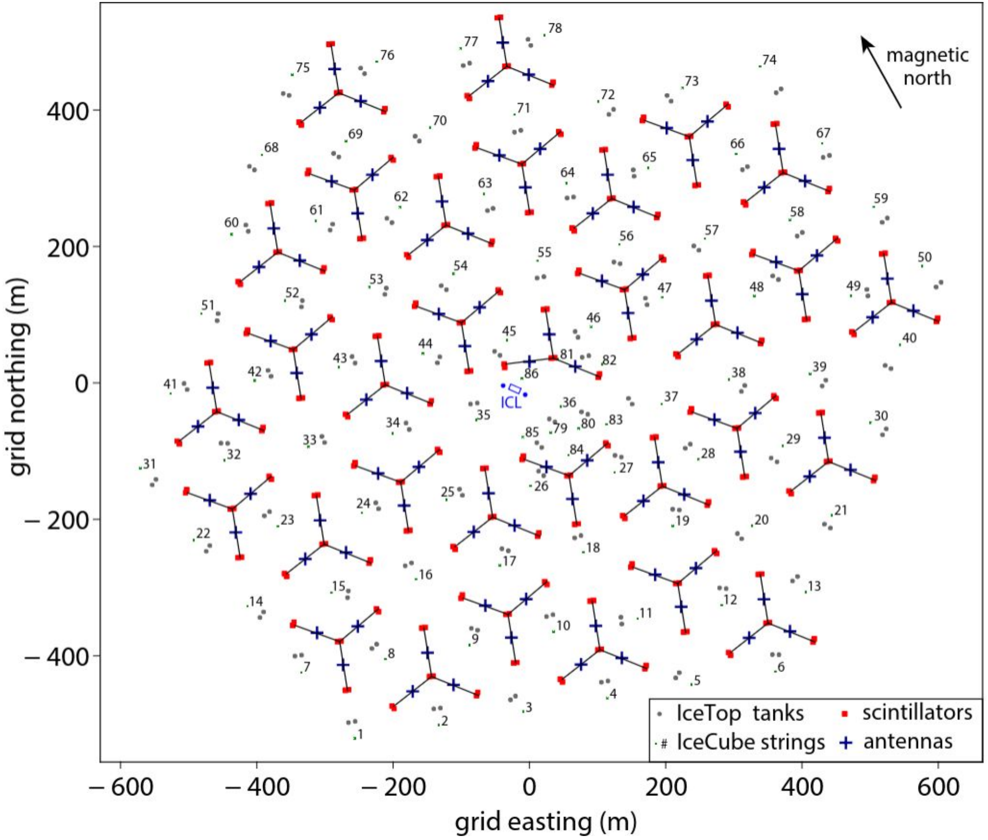
CORSIKA used to generate showers for both IceTop and in-ice detectors

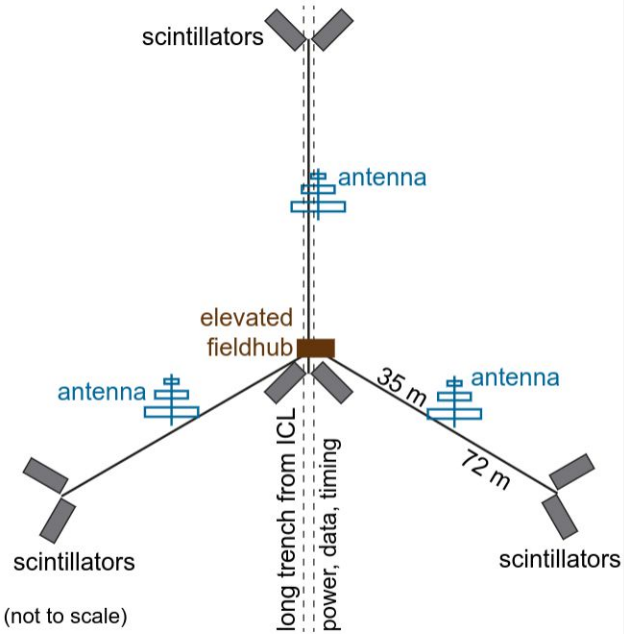
~100,000 simulated shower database constantly being expanded (PeV - EeV)



IceTop and the Future Enhancement

IceTop undergoing an upgrade, includes adding additional detector types





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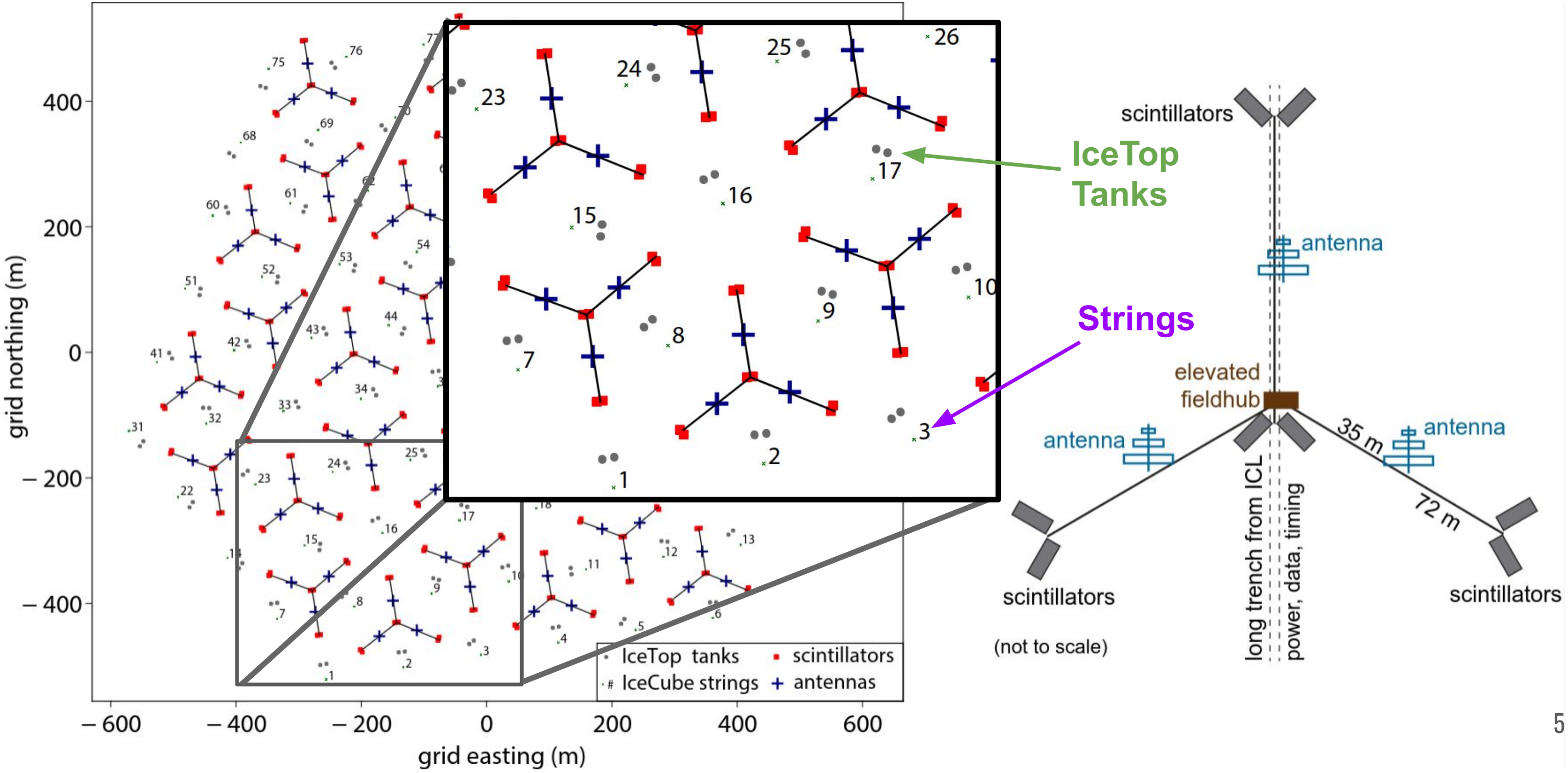


CORSIKA/CoREAS Simulations for Radio

Currently generating a library of 0.1-100 PeV showers for R&D efforts:

1) Determine the optimal layout of the antenna array (mostly complete)

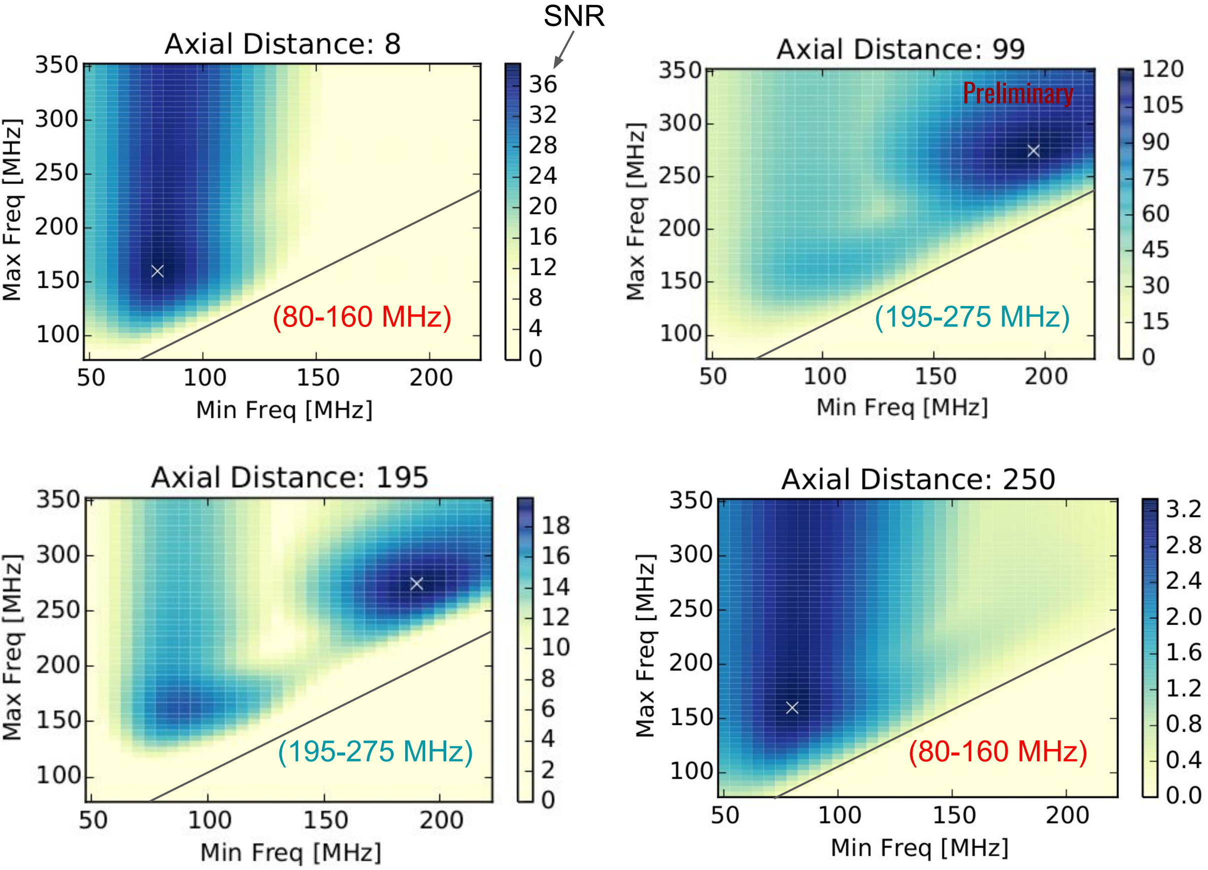
2) Find the optimal frequency bands to analyze the data

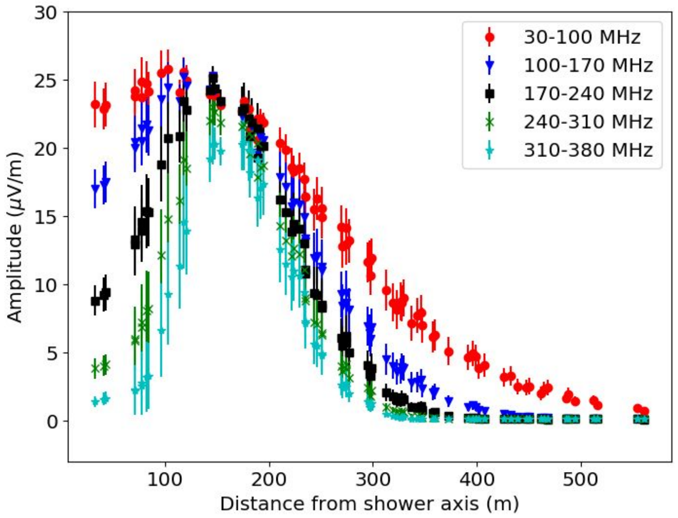
3) Develop initial reconstruction methods

4) Study the general properties of radio emission at the IceTop site

Frequency Band Scans

Primary: 60° 3 PeV



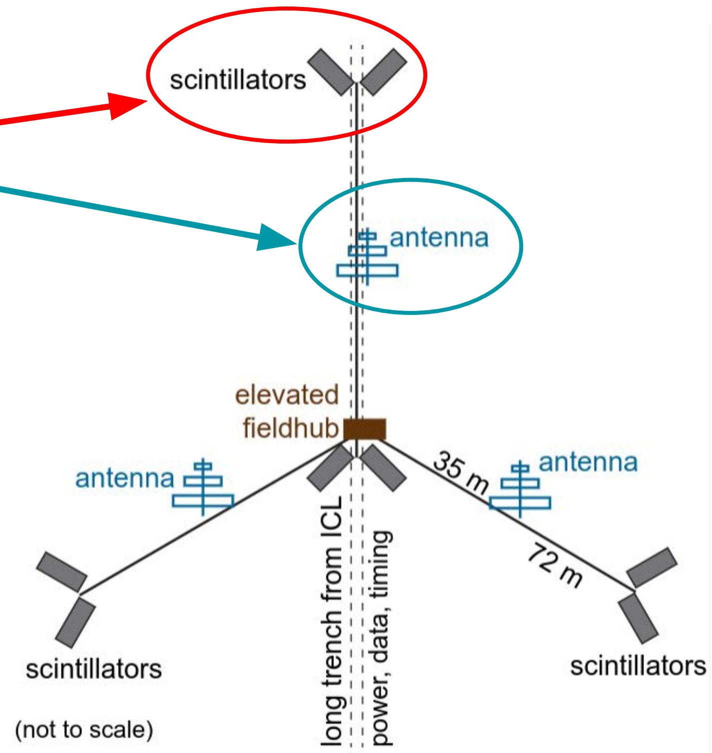


A. Balagopal, et al. (2018)

IceTop and the Upgrade

Similar simulation studies are also being performed for the scintillators

For technical reasons, generating separate shower libraries for scintillators and radio



IceTop and the Upgrade

Similar simulation studies are also being performed for the scintillators

For technical reasons, generating separate shower libraries for scintillators and radio

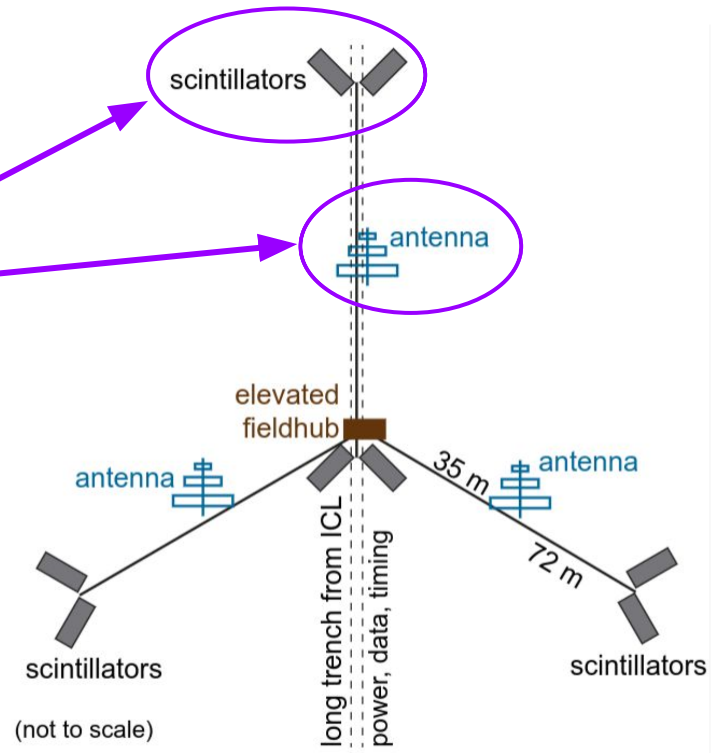
Would like to produce showers for both detectors

Very different requirements for energy cuts (ECUTS)

Scintillators muons > 10MeV

Radios electrons/photons > 0.4MeV

Simulation time takes days for unthinned showers with energies > 0.5PeV using CoREAS

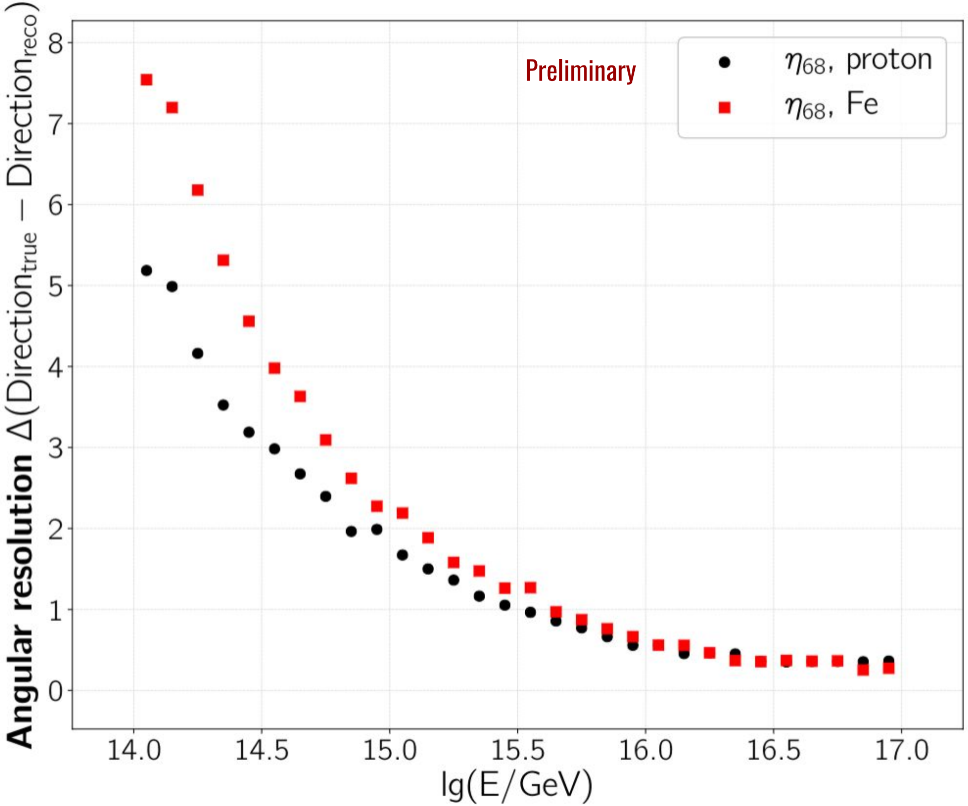


Simulation Results for Scintillators

Already created a large library of showers at KIT for the study of the scintillator + IceTop

Initial reconstruction algorithms have been completed

Beginning to study the precision of the reconstruction and applying this to the data being collected by the prototype array



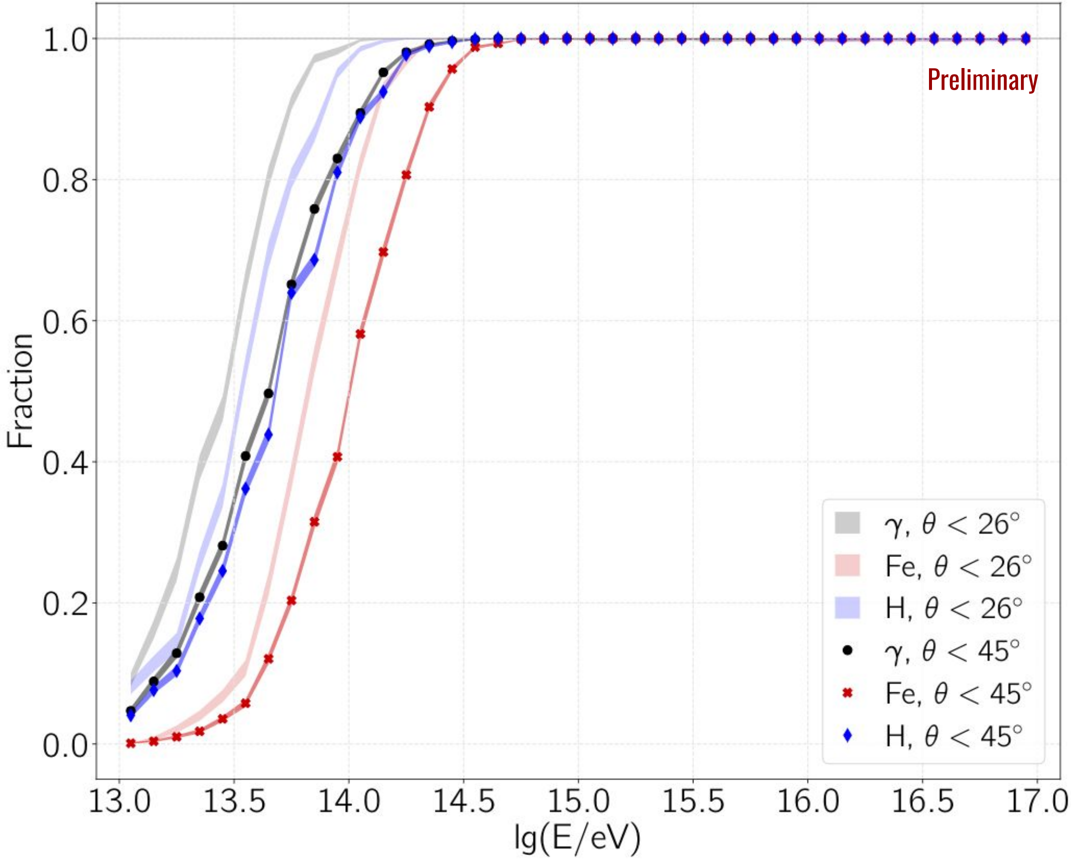
Plot by Agnieszka Leszczynska (KIT)

Simulation Results for Scintillators

Characterizing the air shower detection capabilities of the scintillator array

Array optimized to lower the energy threshold

Improvement by more than order of magnitude in energy compared to IceTop



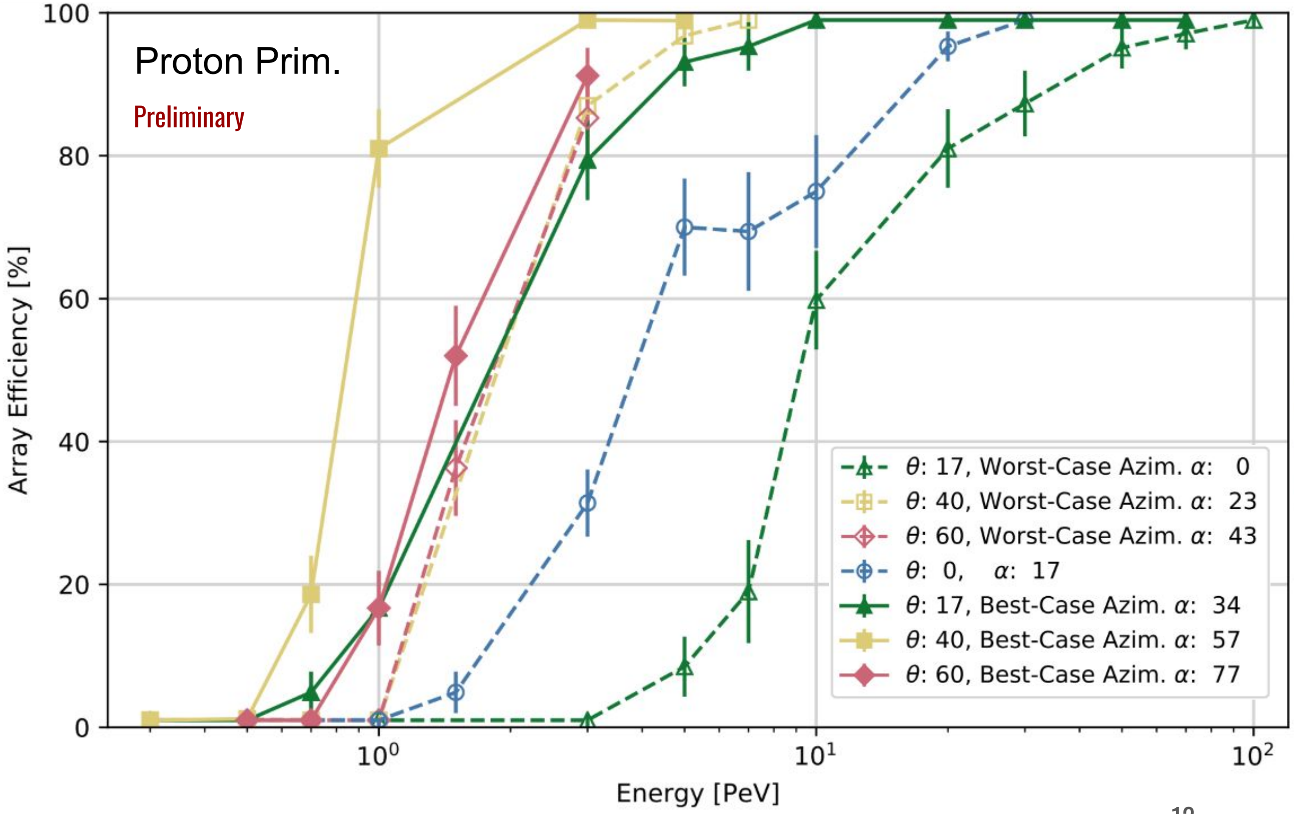
Plot by Agnieszka Leszczynska (KIT)

Simulation Results for Radio

Efficiency studies also ongoing for hybrid radio-scint detection

Require at least three antennas with SNR > 10 in scint-triggered stations

Much smaller statistics



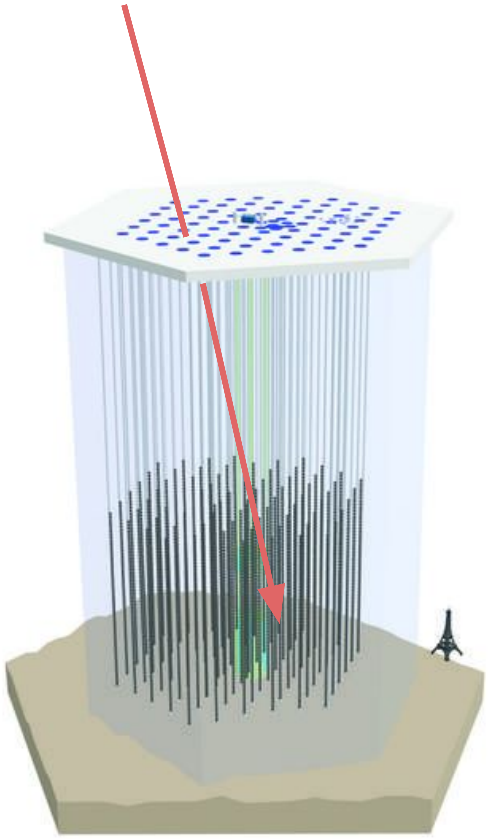
Combined Detector Simulations

The goal is to have a library which can be used for four detector types:
IceTop, Scint, Radio, and In-Ice

The major bottlenecks are:

Radio → CoREAS takes ~days

In-Ice → Detector simulation
→ Many "non-interesting" events for CR studies



Looking Ahead

Develop more advanced reconstruction methods to calculate mass-estimators:

1. Fitting the lateral distribution of EM/Muons separately
   a. Requires simulations of the individual secondary particle types
   b. Allows for an estimation of the relative particle count in the shower

2. Estimating the depth of shower maximum using the radio array
   a. Requires a large library to fully span the parameter space!
   b. Need heavier primaries to explore Xmax ranges

Further, create a combined reconstruction for the four detectors at IceCube

Wish List and Conclusions

1. Faster generation of showers with radio emission, either:
    a. Parameterized radio emission to be run with standard CORSIKA output
    b. Some creative use of thinning for only the radio part (MULTITHIN?)
2. Heavier primaries than iron to study the wide Xmax range
3. Ability to cancel shower generation which are outside of a selected subspace
    a. IceCube is only triggered by showers with >273GeV muons, could kill many showers early
4. Simulate complete radio footprint, not just antenna positions
5. Store Poynting Vector

CORSIKA/CoREAS are crucial tools to develop the IceTop enhancement

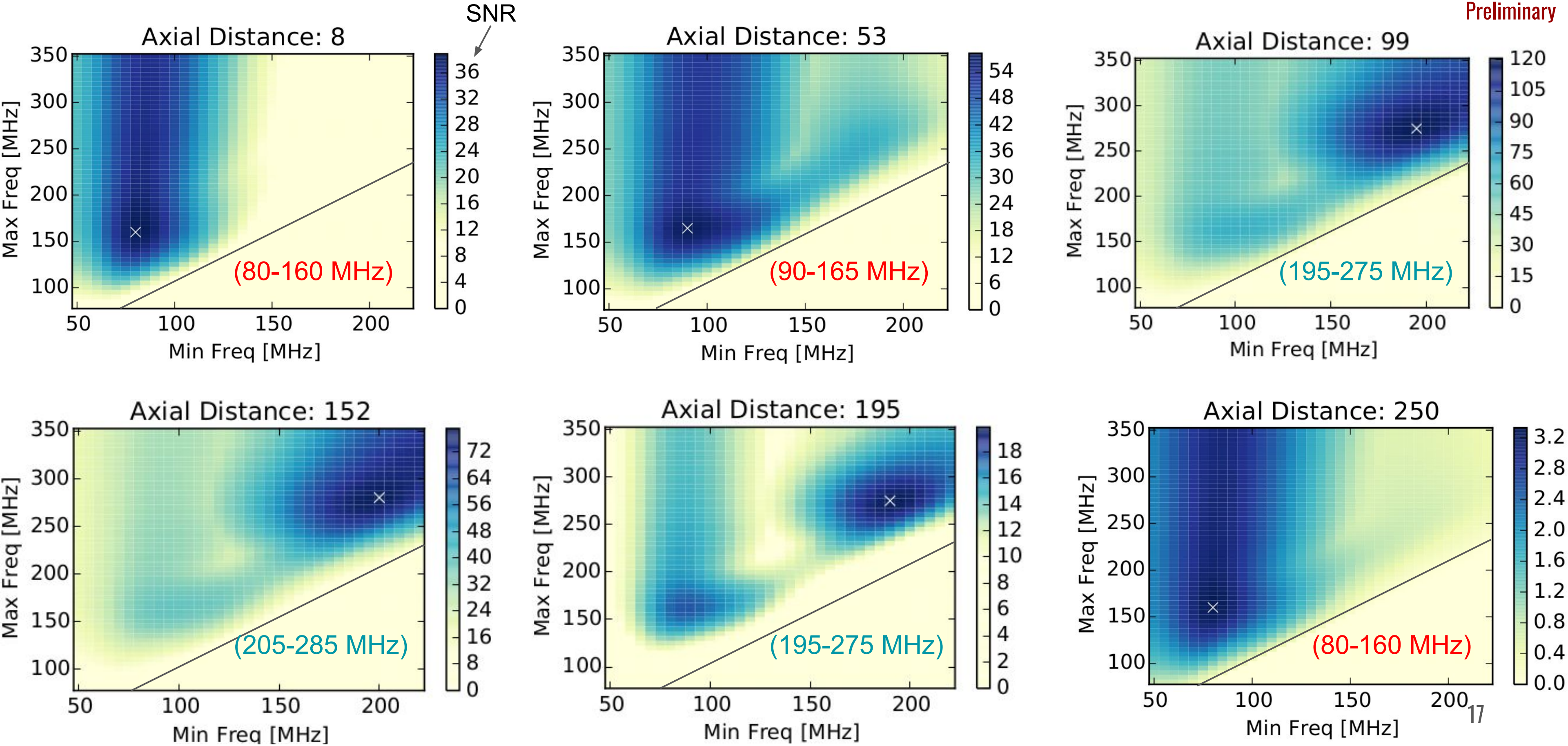
Already being used in early R&D studies of the radio emission at the pole, detection capabilities, etc.

Working towards a combined reconstruction with all four detector types

Frequency Band Scans

Primary: 60° 3 PeV

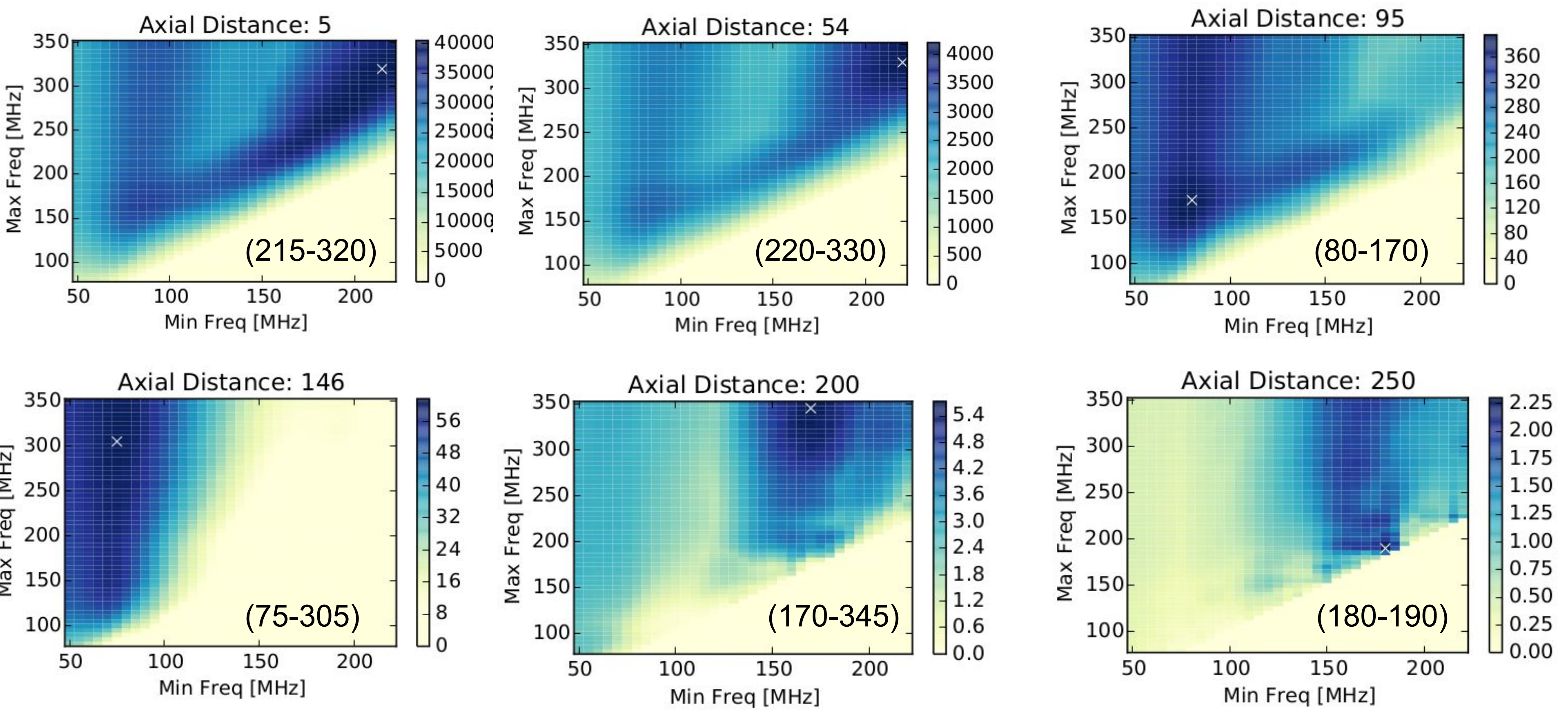
Preliminary



Frequency Band Scans

Primary: 17º 100 PeV

Preliminary



Simulated Radio Waveforms

Preliminary