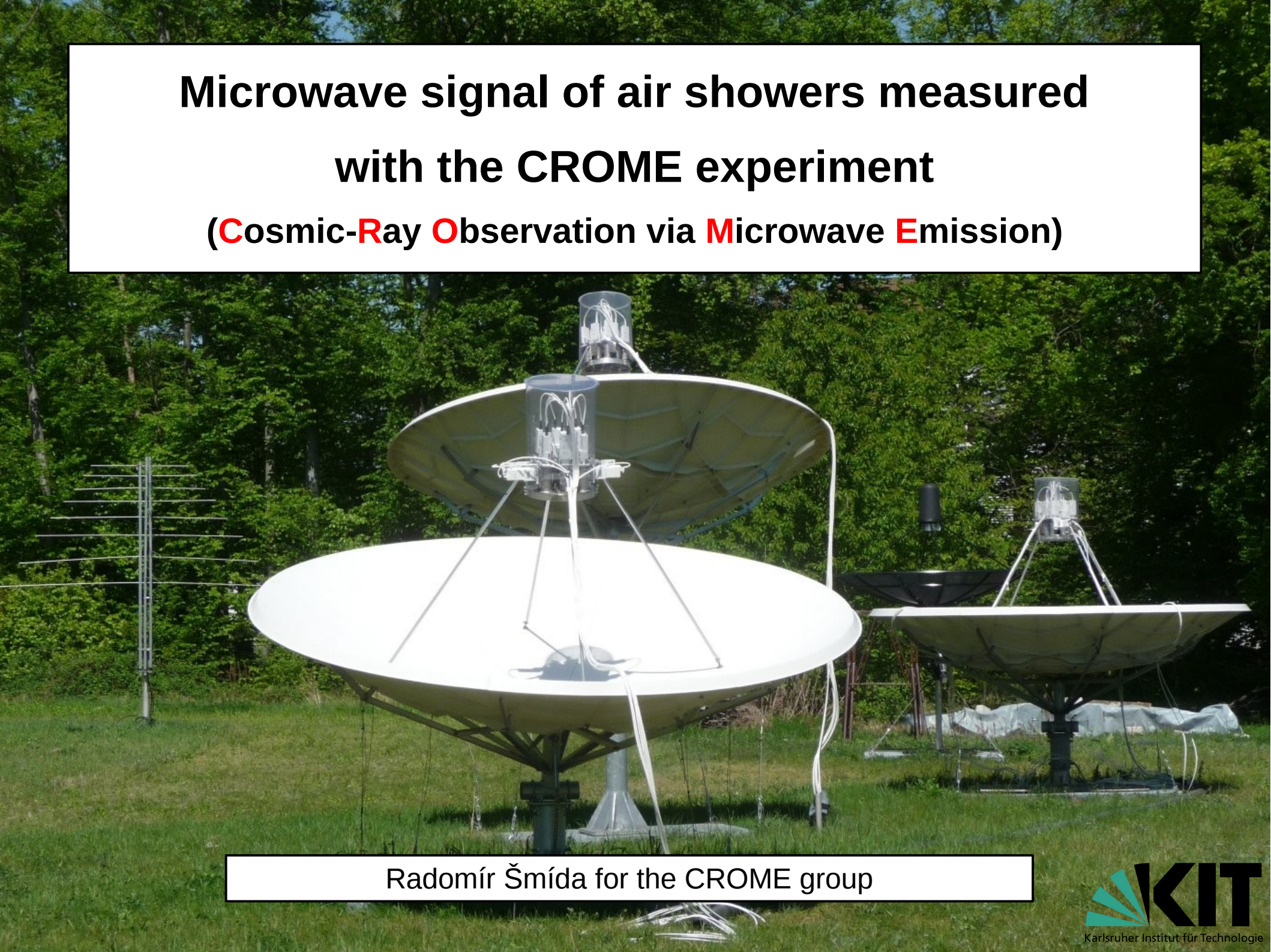
Microwave signal of air showers measured with the CROME experiment

(Cosmic-Ray Observation via Microwave Emission)



Radomír Šmída for the CROME group

Karlsruher Institut für Technologie

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☑ Done.
F. Werner, PhD thesis (2013)
R.Š. et al., Phys. Rev. Lett. 113 (2014) 221101

Motivation:

Appealing idea of a high-duty cycle, calorimetric and mass sensitive measurement of cosmic-ray extensive air showers.

1) Isotropic (molecular bremsstrahlung) emission in the microwave range
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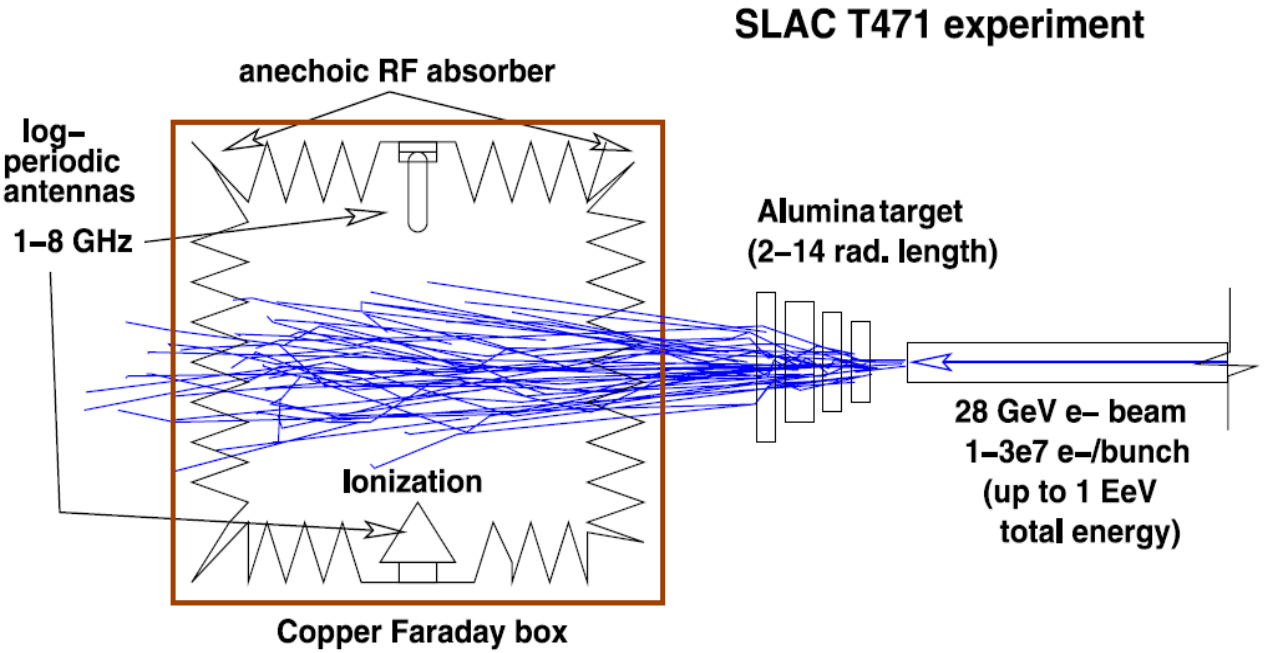

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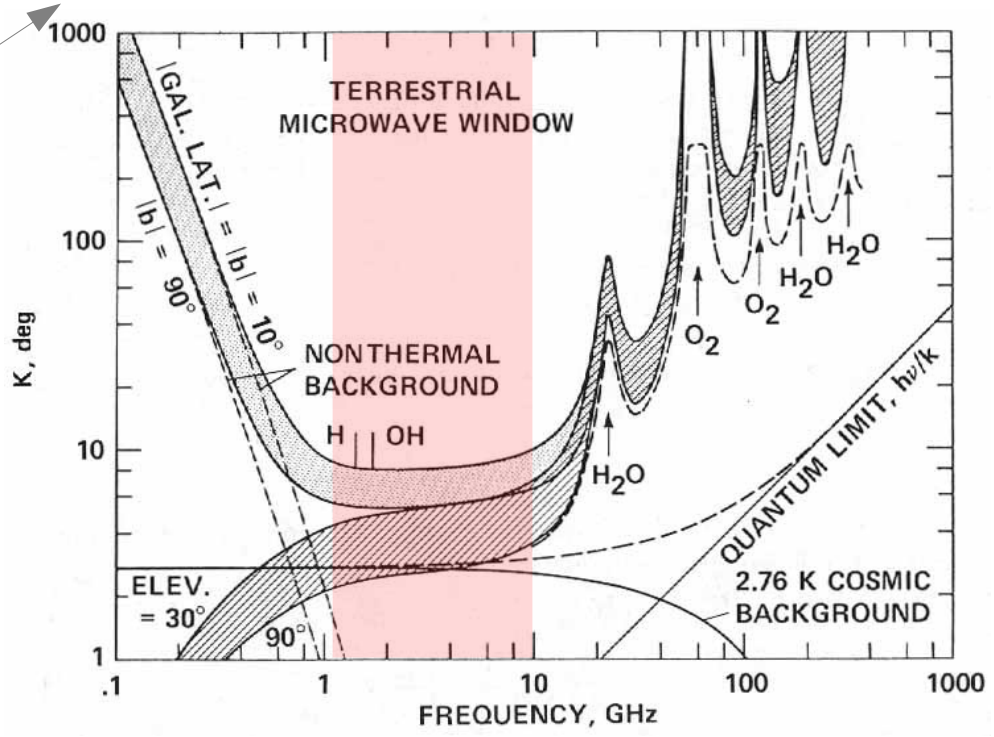
Radio
(30-80 MHz)



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Can a GHz receiver substitute a PMT?

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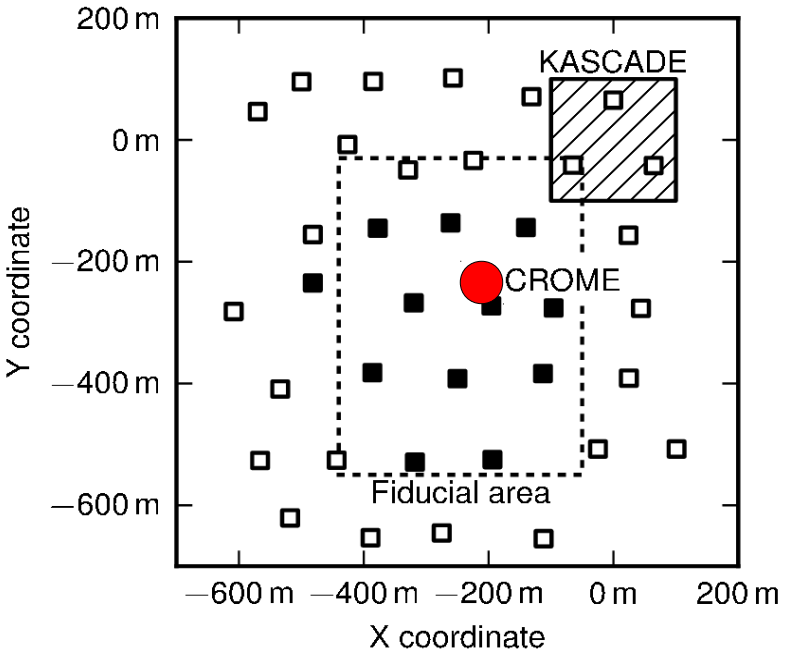
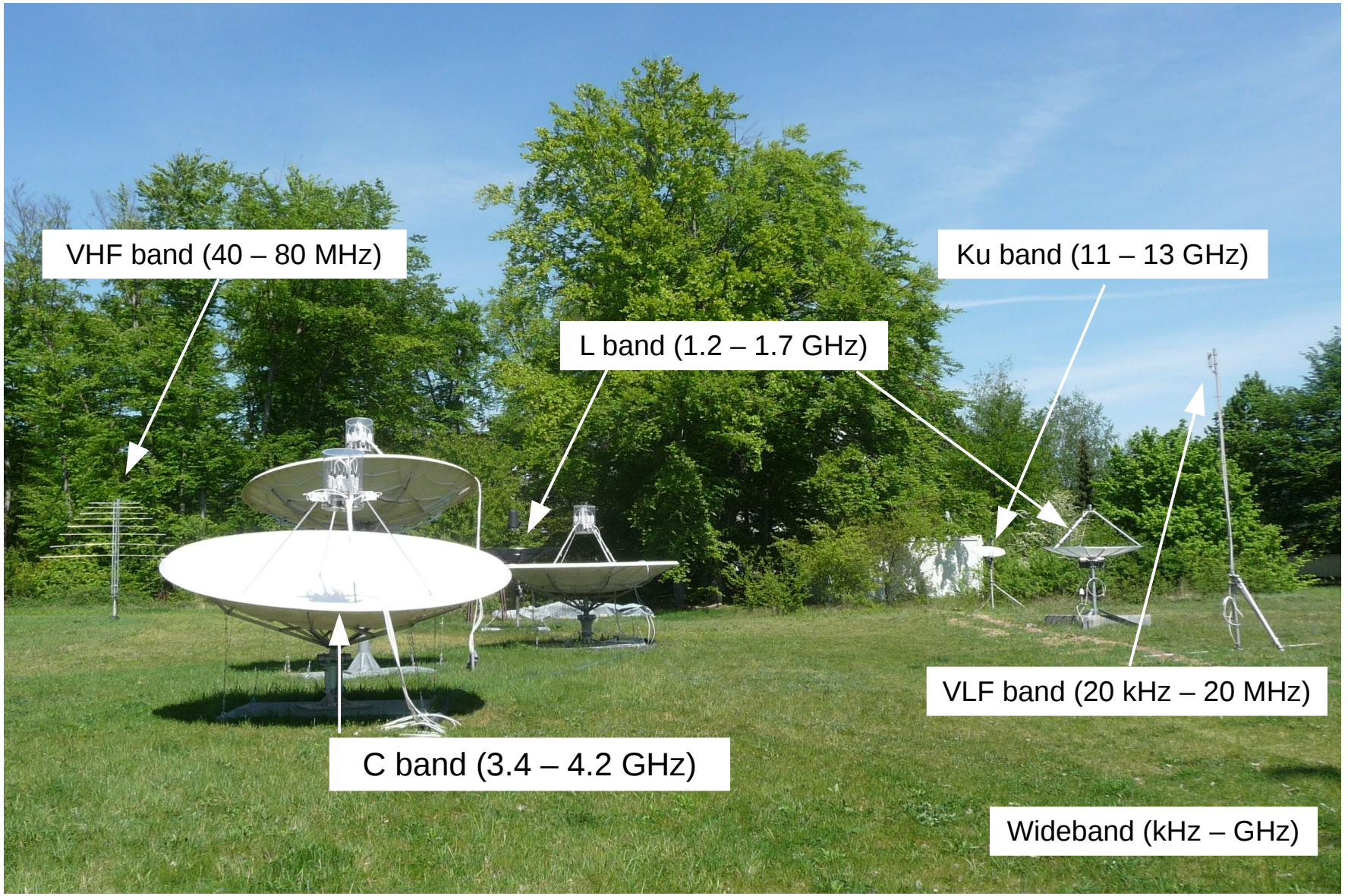
KASCADE-Grande array



Showers btw 10^{16} - 10^{18} eV

KG provided:
- External trigger
- Offline reconstruction

The CROME experiment in its heyday (mid 2012)



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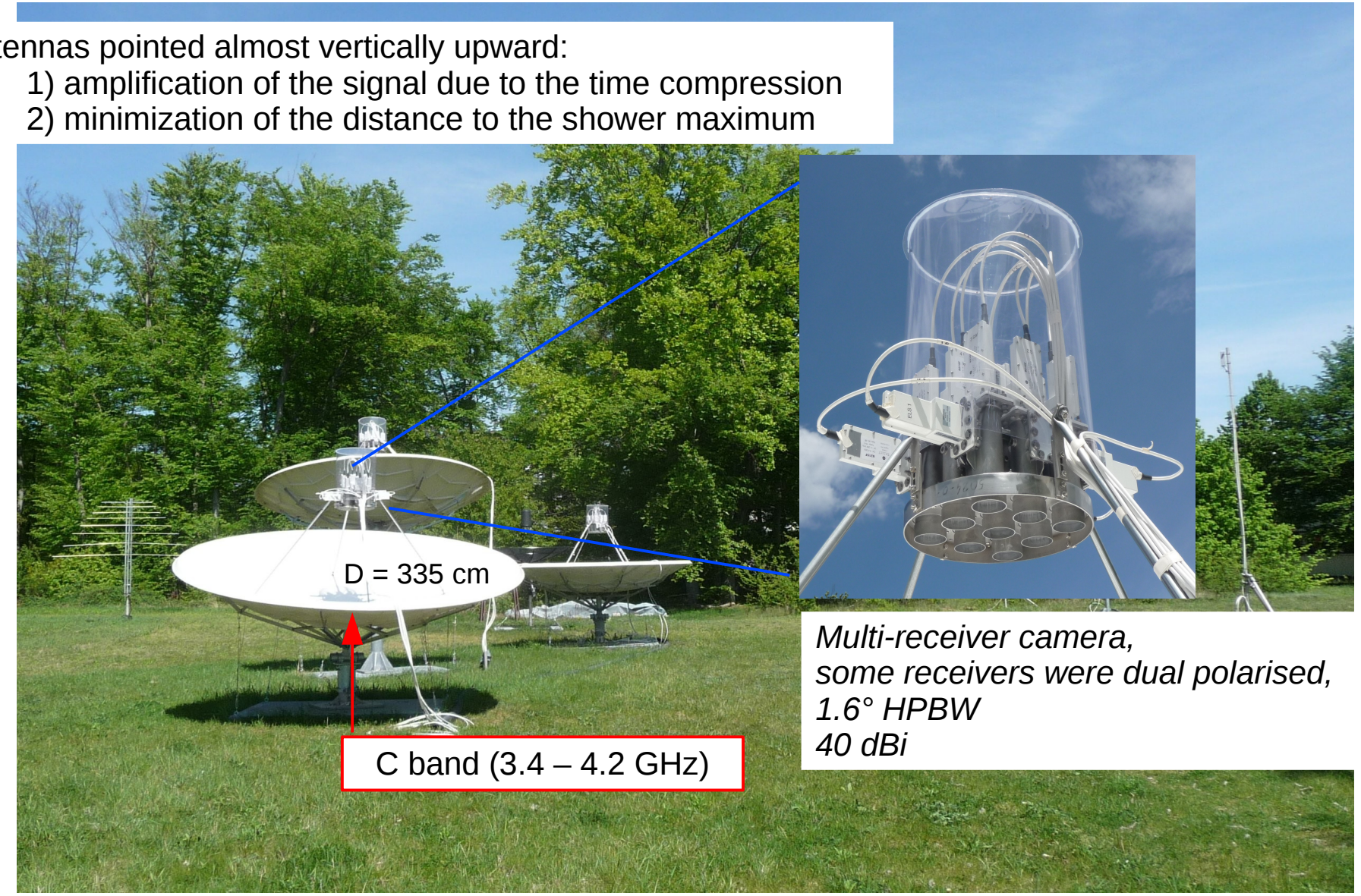
Antennas pointed almost vertically upward:

1) amplification of the signal due to the time compression
2) minimization of the distance to the shower maximum



Multi-receiver camera,
some receivers were dual polarised,
1.6° HPBW
40 dBi

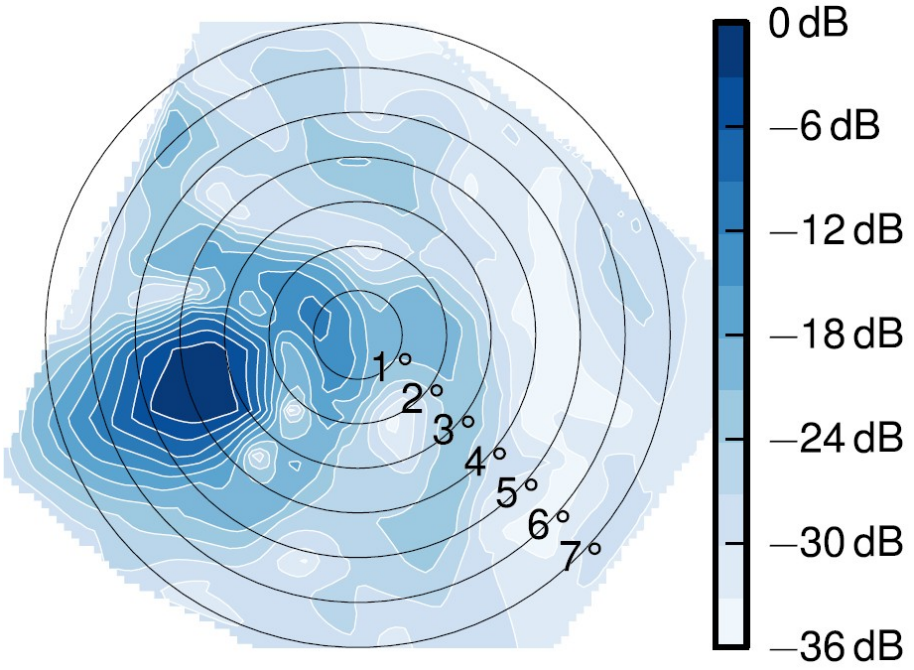
Performance:

12K hours of common operation w/ KG between between May 2011 and Nov 2012 after applying quality cuts

15k events above $10^{16.5}$ eV and zenith below 40 deg

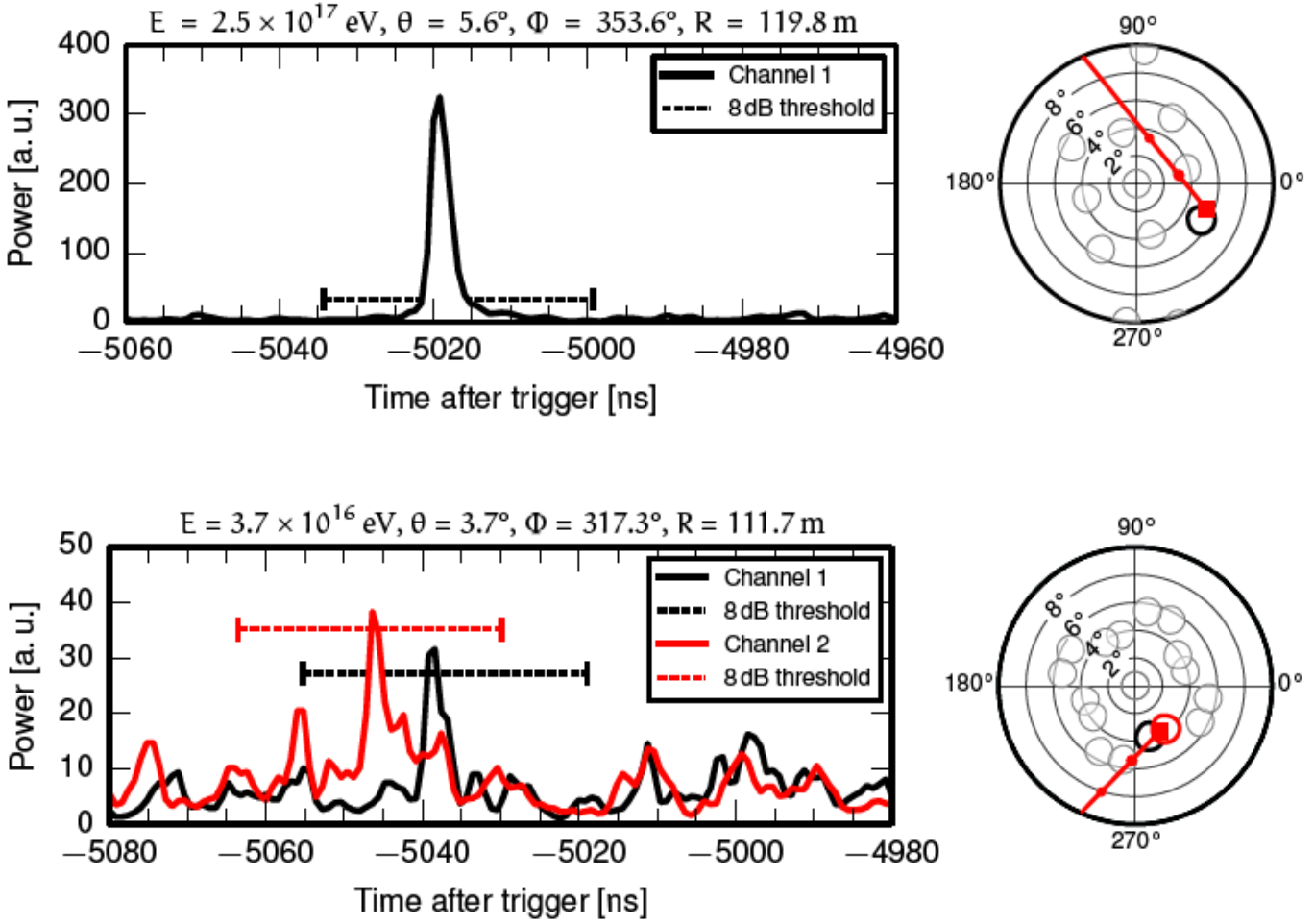
3.7k crossed the f.o.v. of the antennas

The mw signal was measured for > 30



Events:

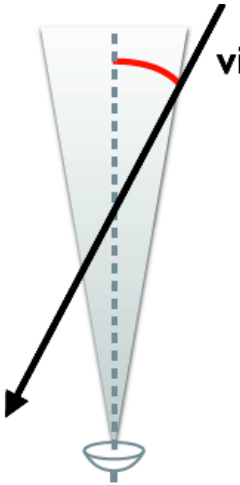
On next pages: Felix Werner, ARENA 2014



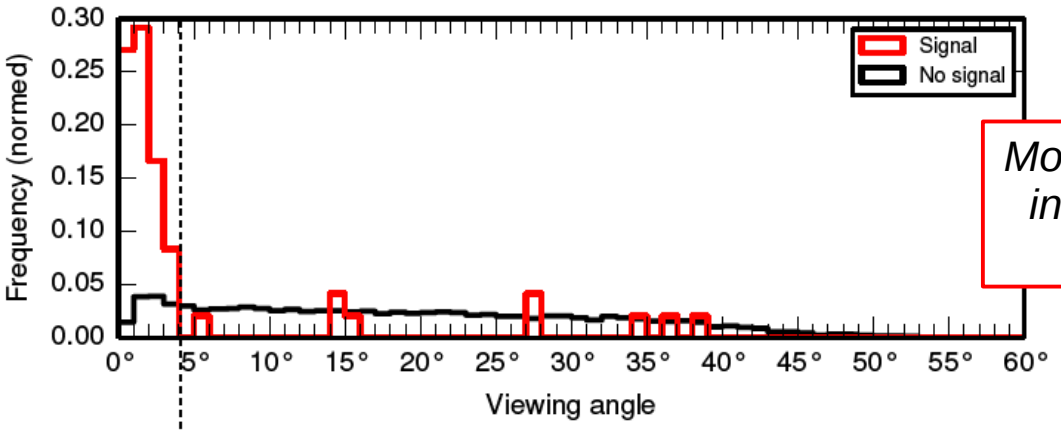
Common properties:

- short pulses (~5 ns)
- mostly single-receiver (only two stereo events)
- emission seems forward-directed
- signals originate from >2 km

Event properties I.:



viewing angle: $\sphericalangle$ (channel boresight, shower axis)



Most signals are detected in the forward region of the air showers

'forward' sample
39 signals
exp. <4 noise (95% C.L.)

'isotropic' sample
9 signals
exp. 11 noise

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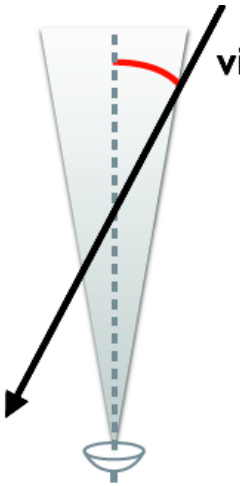

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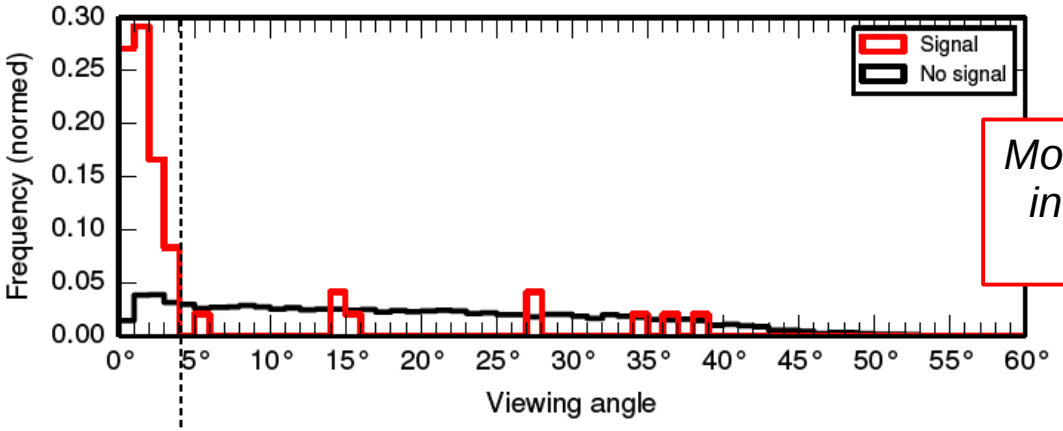

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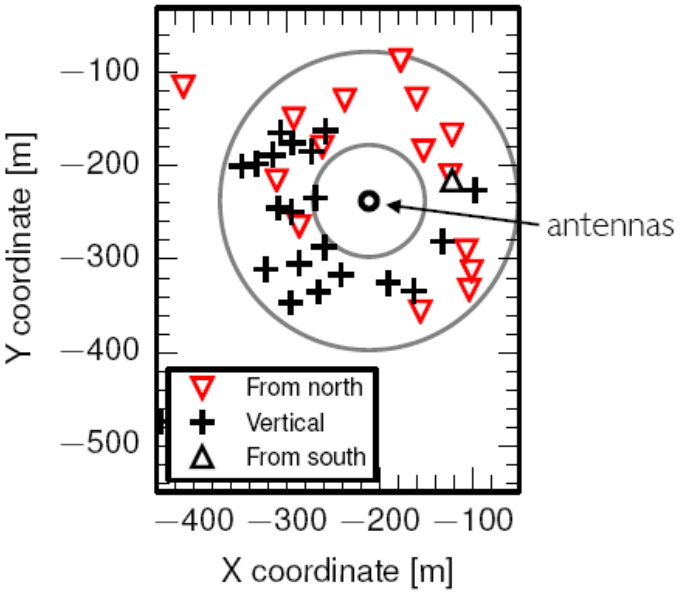
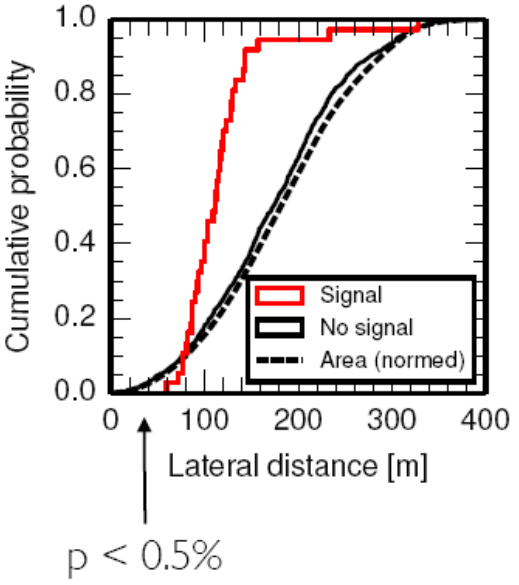
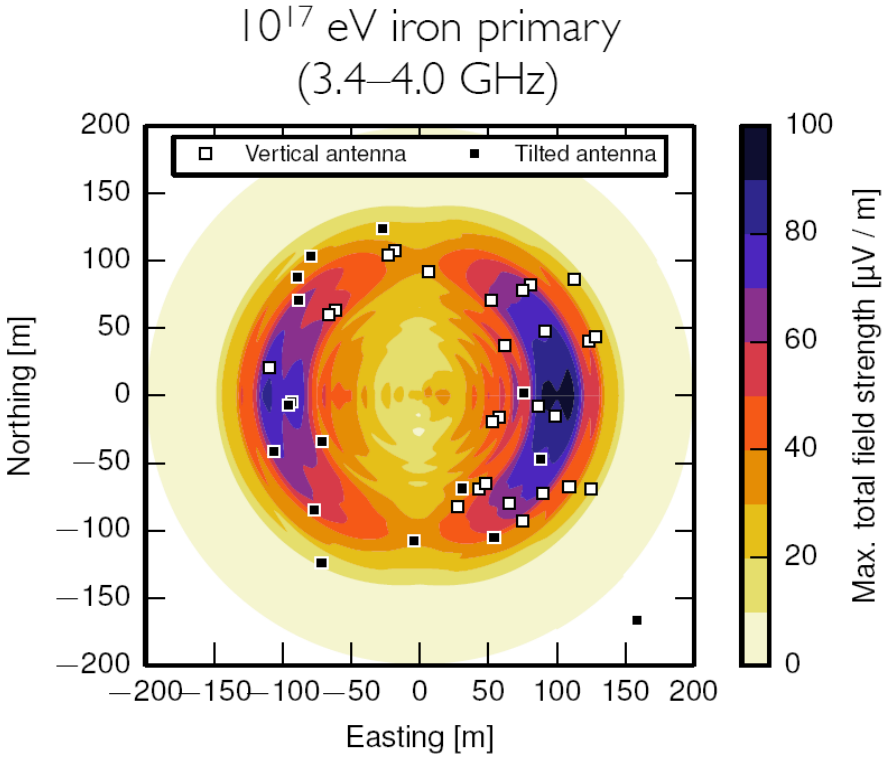
Core position:
- *ring structure*
- *EW asymmetry in a vertical antenna*





Event properties II.:

Signal simulated in CoREAS



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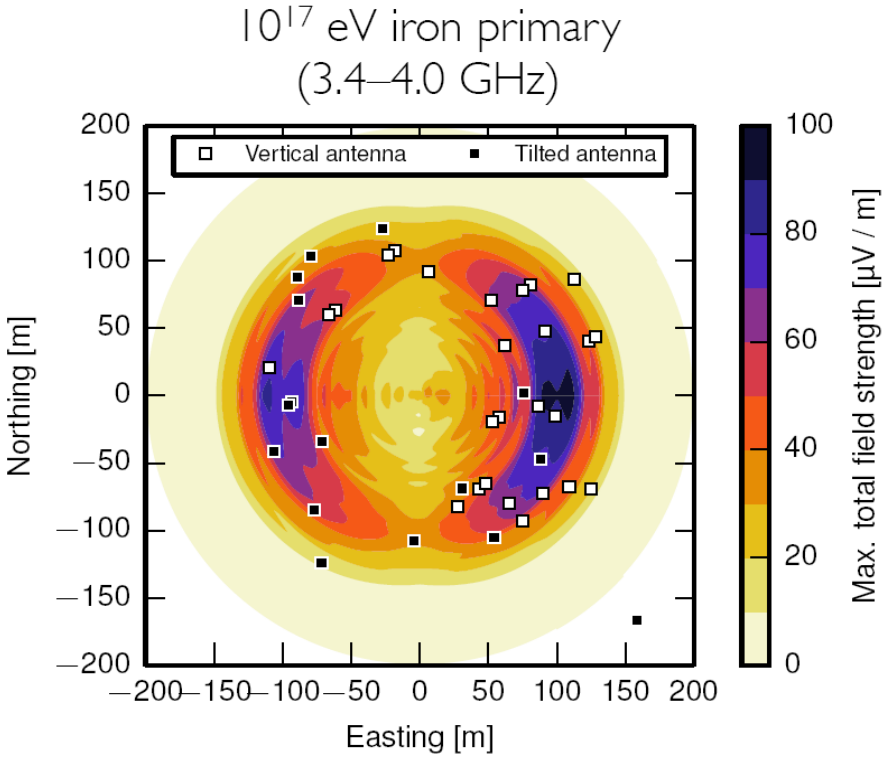
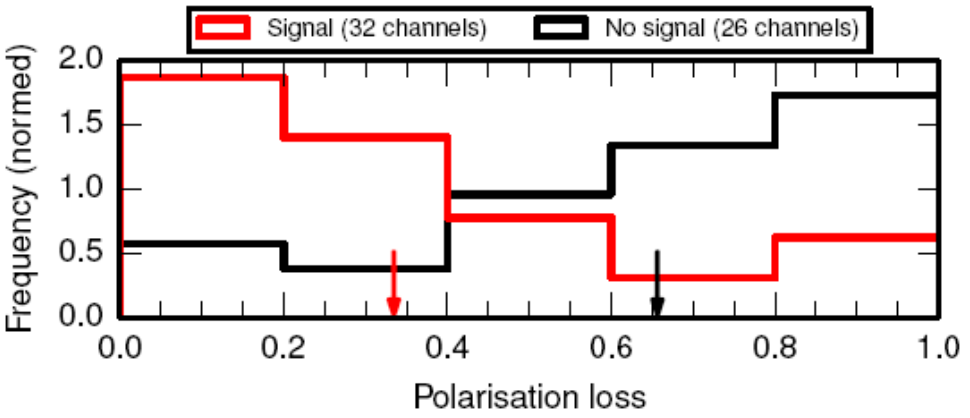


Measured signal is polarised

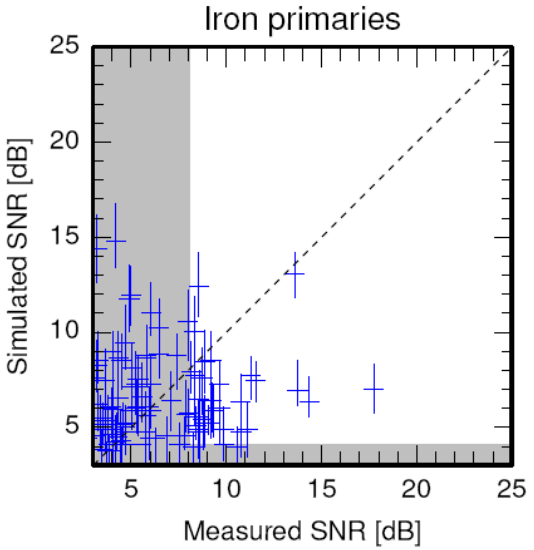


incompatible with unpolarised radiation at 4.7σ level

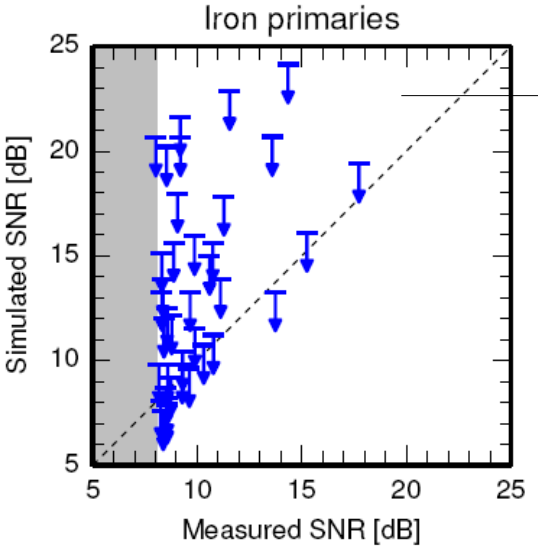
Our results:

a) Clear idea about the major emission mechanisms of the mw radiation
- Time compression near the Cherenkov cone
- Highly forward-beamed signal
- Polarised signal

b) The isotropic component is much smaller than predicted
- Has not been detected yet
- Preliminary: below 10% at 10^{17} eV



MBR simulations



Not all signal losses were implemented.

CoREAS simulations

c) Our results have been beneficial also for understanding the radio signal at lower frequencies and development of simulations

Thank you!

Block diagram: