

Probing atmospheric electric fields in thunderstorms through radio emission from air showers

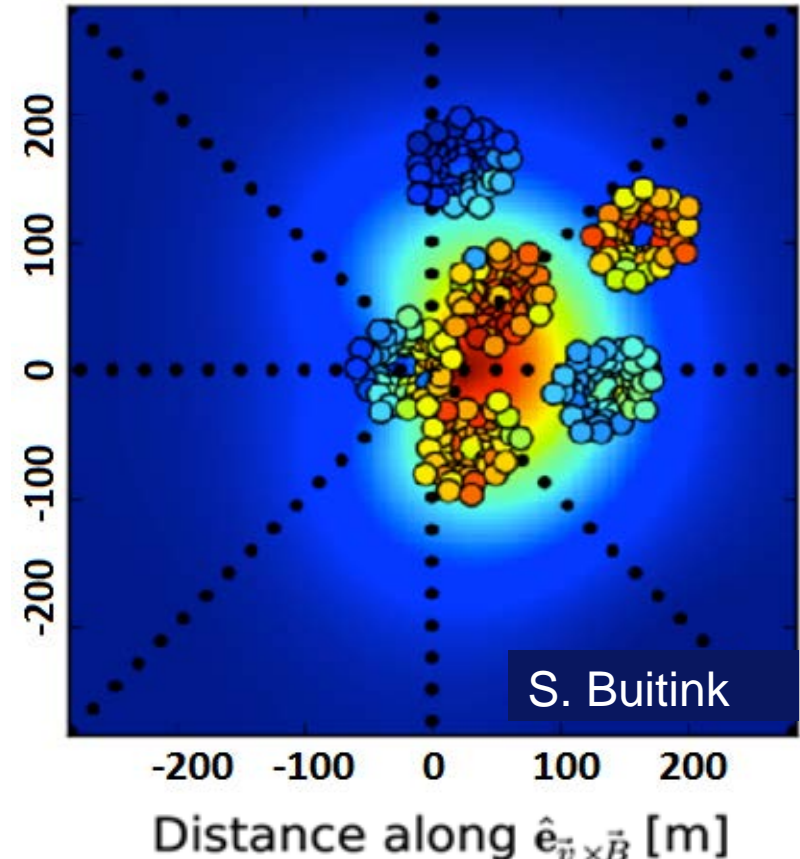
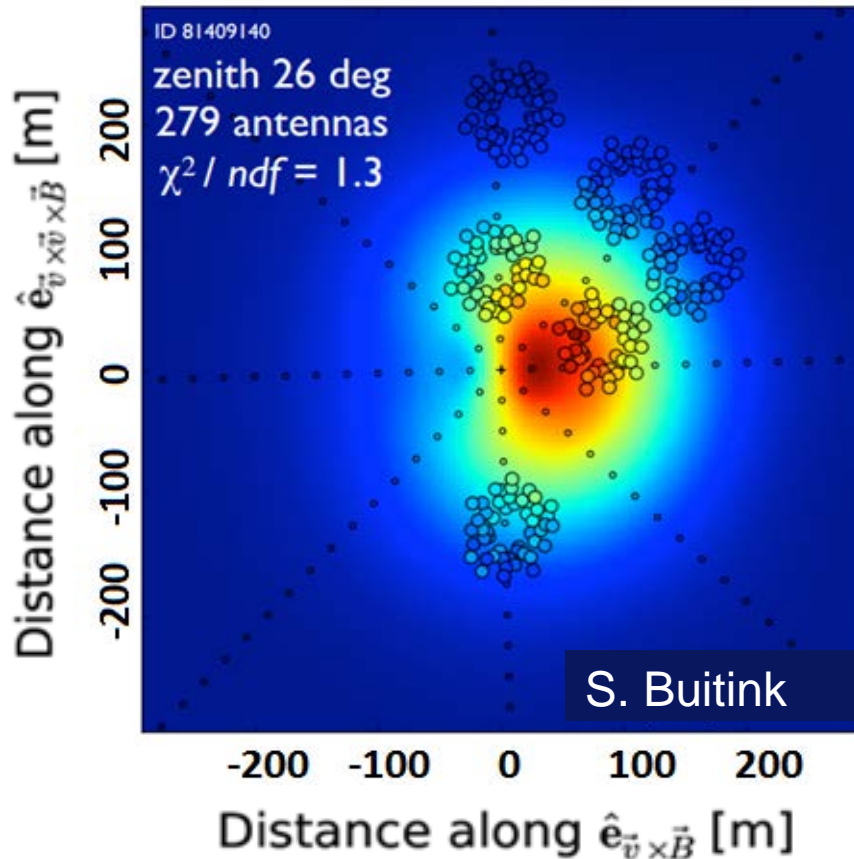
Gia Trinh

LOFAR Cosmic Ray KSP & Cosmic Lightning Project

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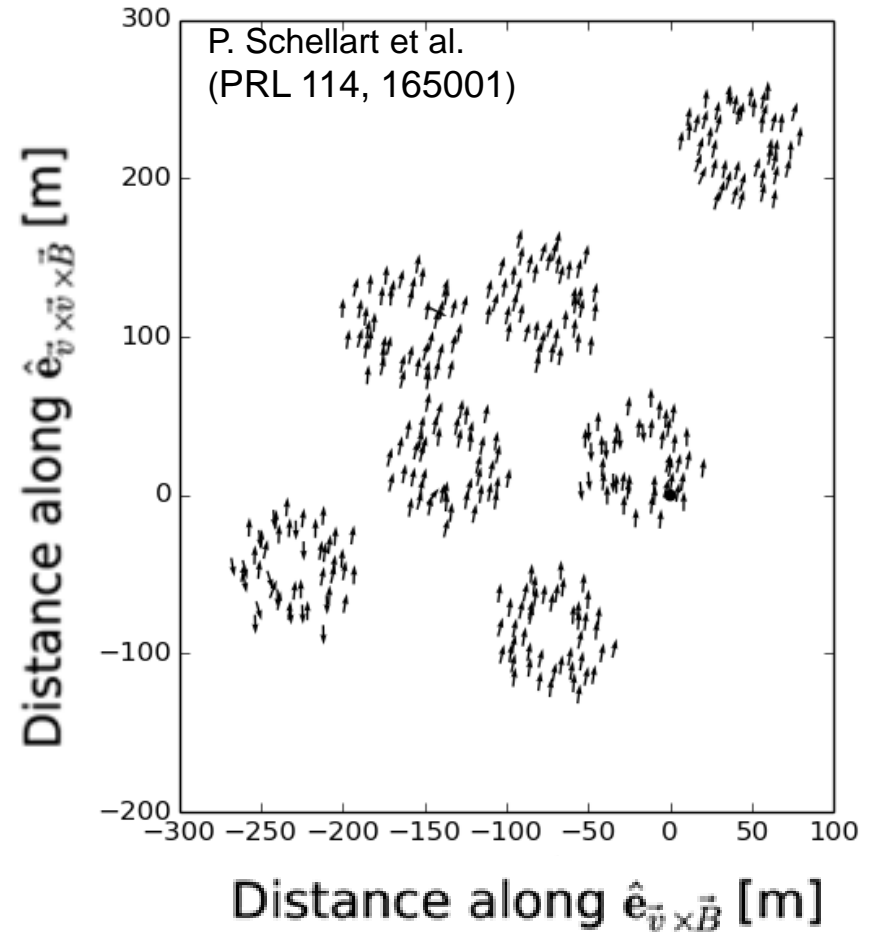
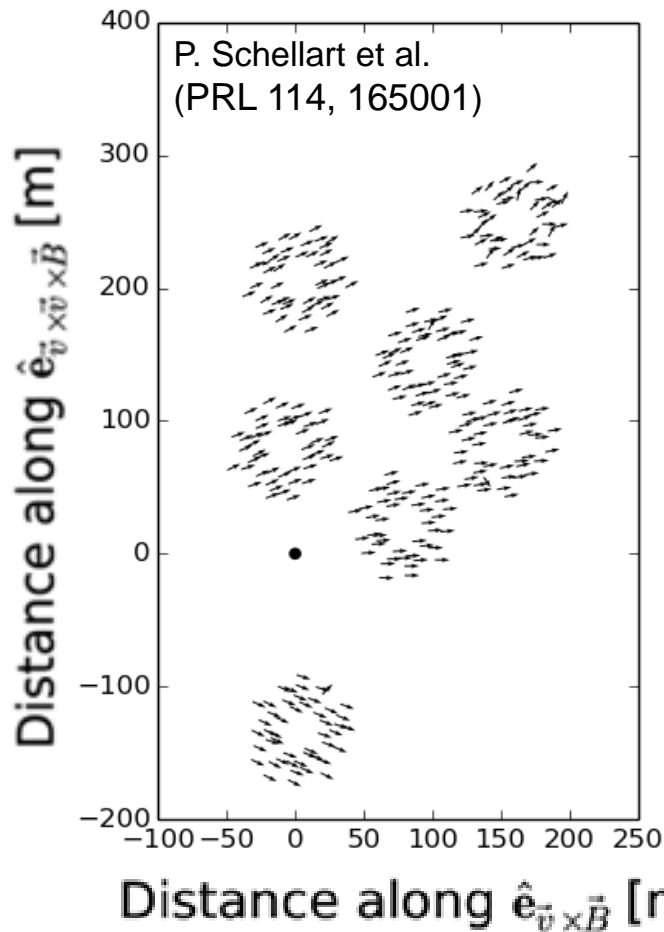
Fair weather vs thunderstorm



Intensity footprint



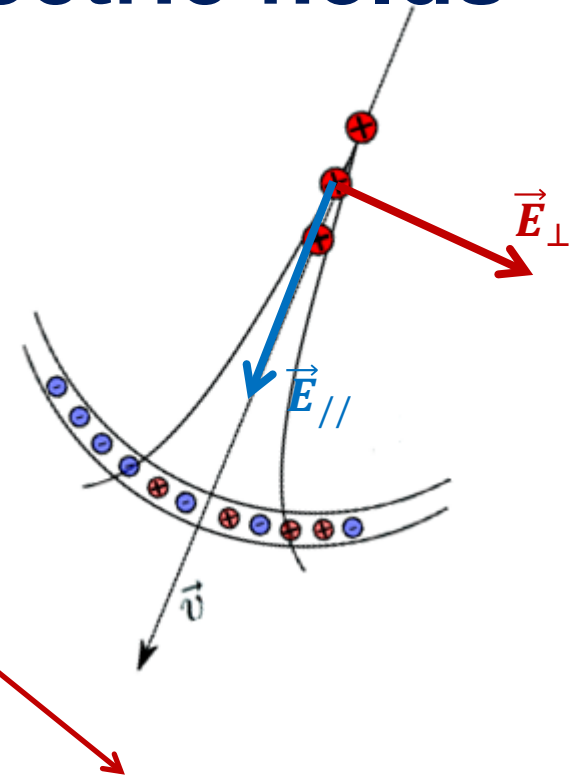
Fair weather vs thunderstorm



Polarization footprint

Effective atmospheric electric fields

$$\vec{E} = \vec{E}_{//} + \vec{E}_{\perp}$$



Charge-excess component

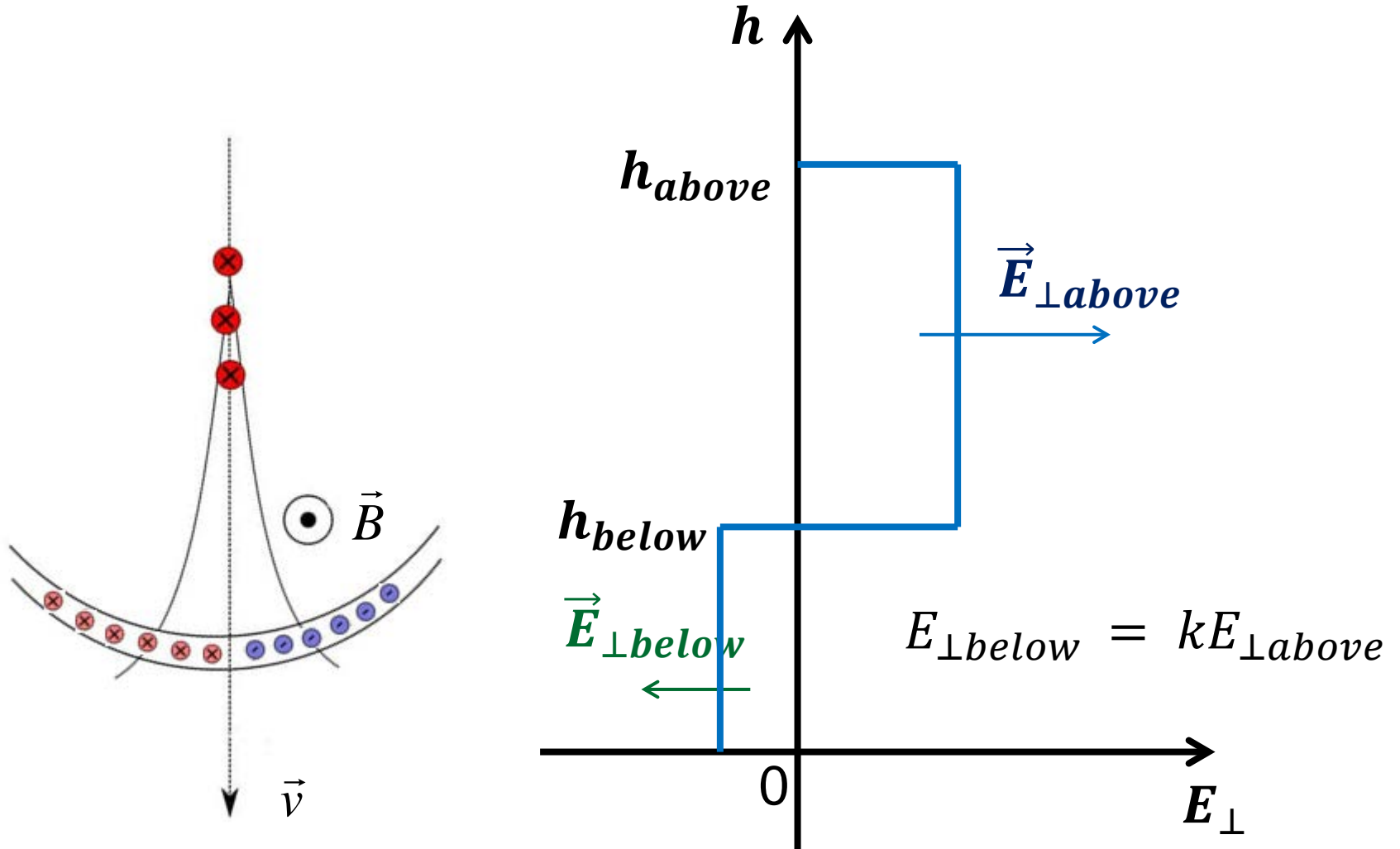
- ◆ Amplitude: 0/+
- ◆ Polarization: more radial

Transverse-current component

- ◆ Amplitude: ++
- ◆ Polarization: direction changes

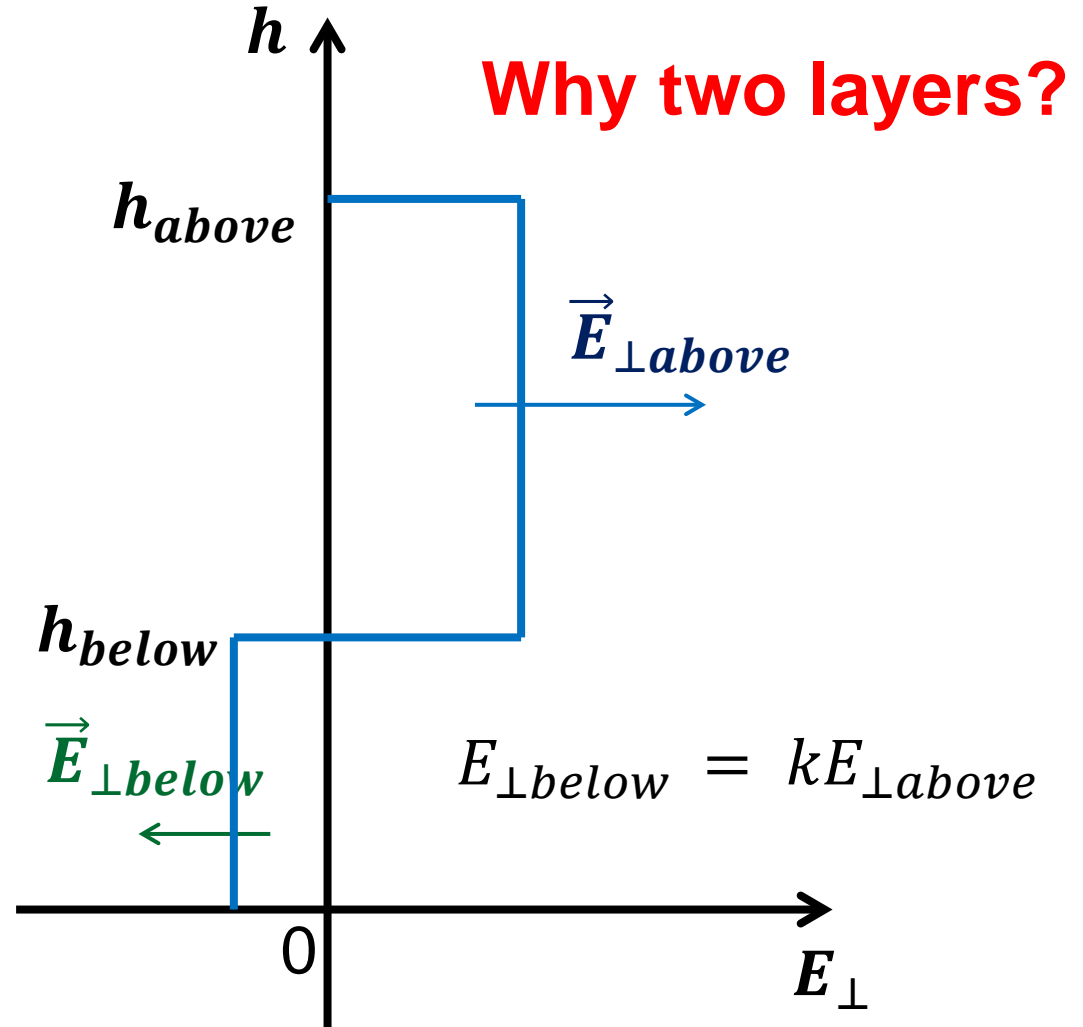
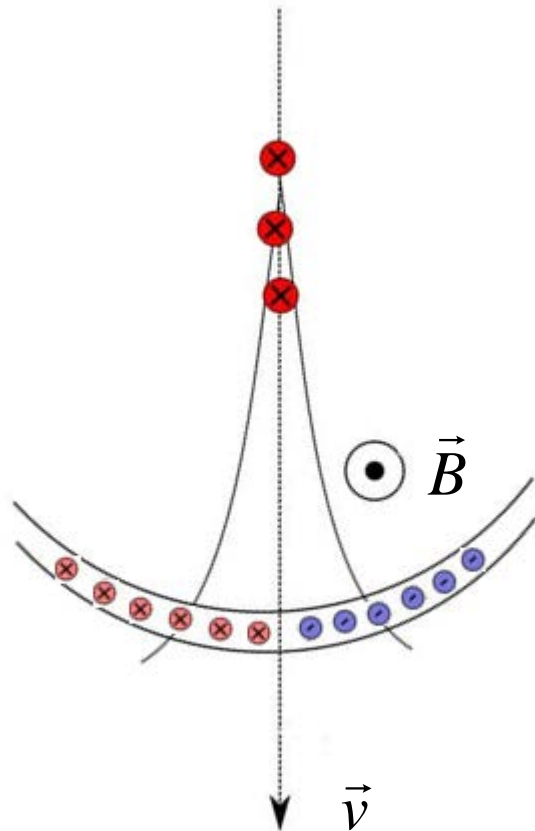


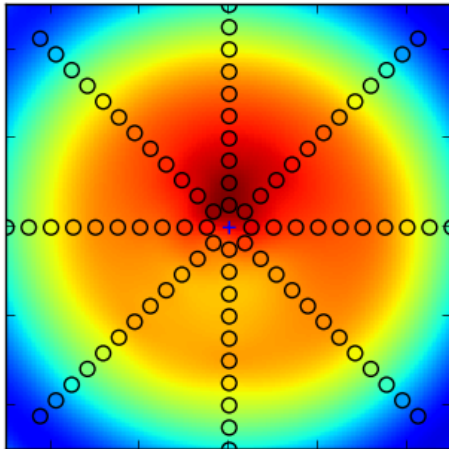
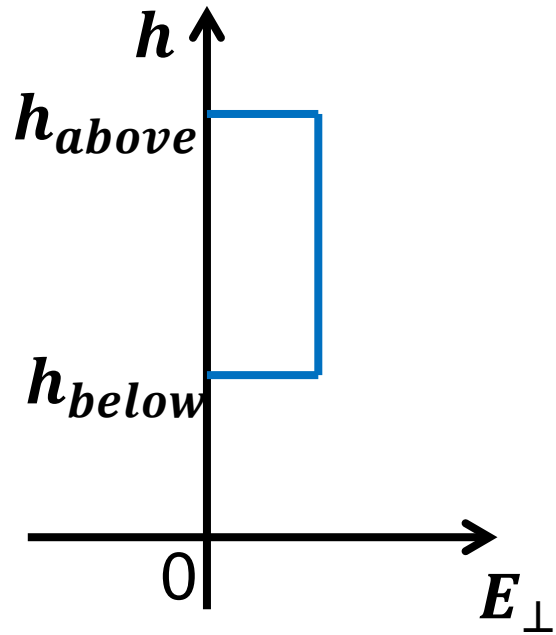
A two-layer model of E-fields

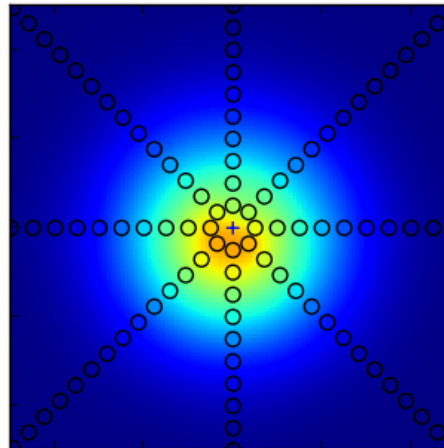
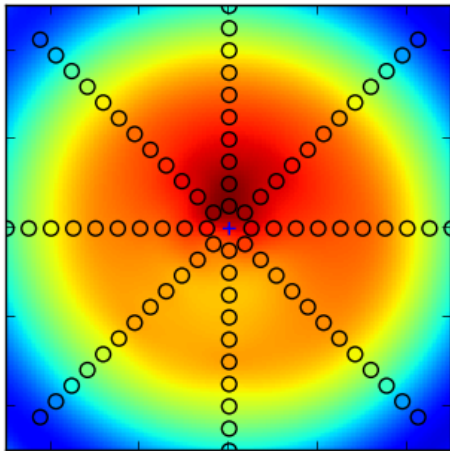
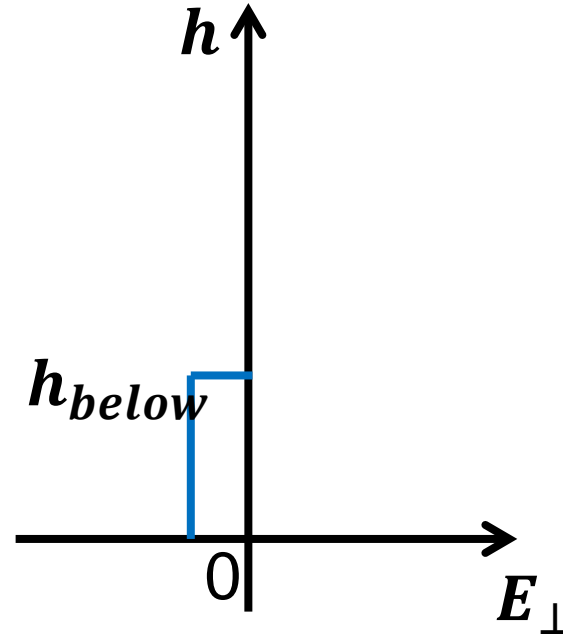
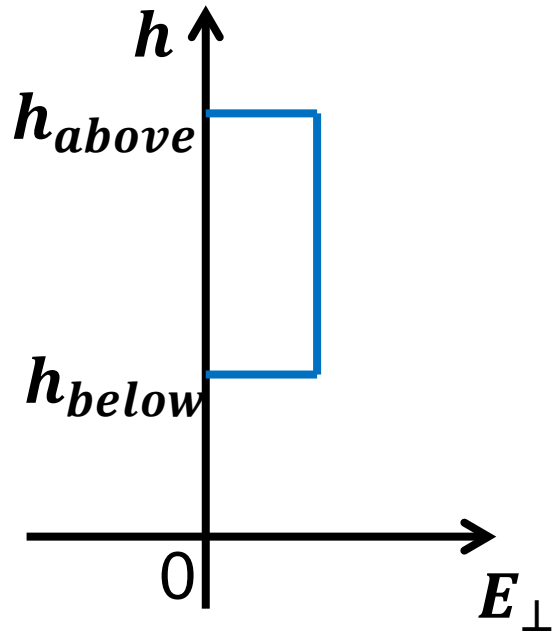


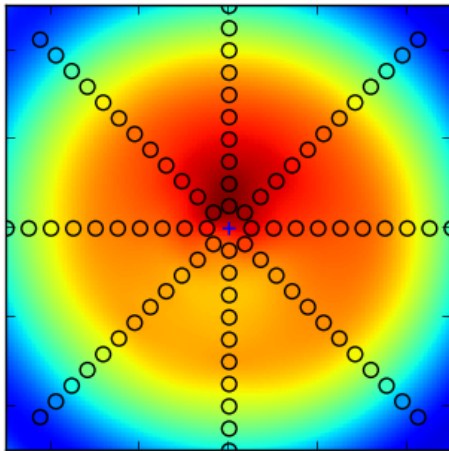
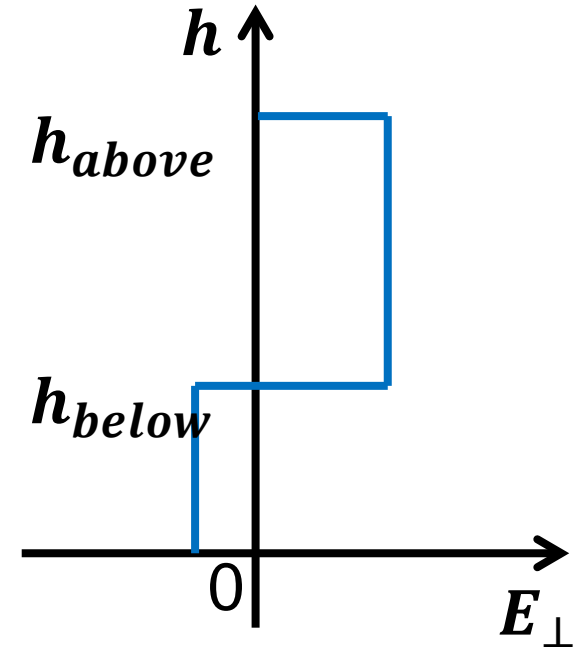
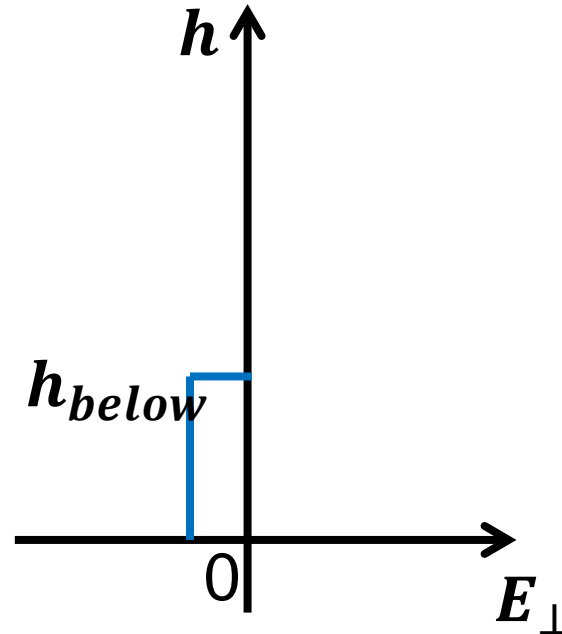
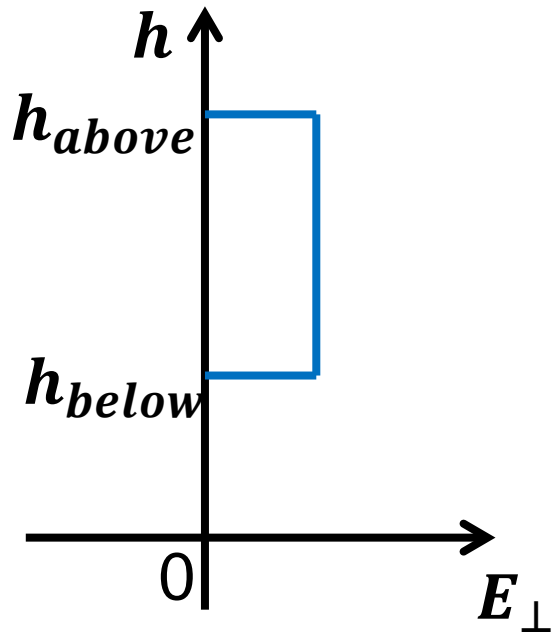


A two-layer model of E-fields

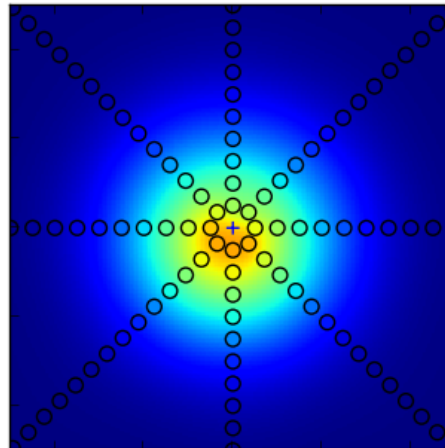




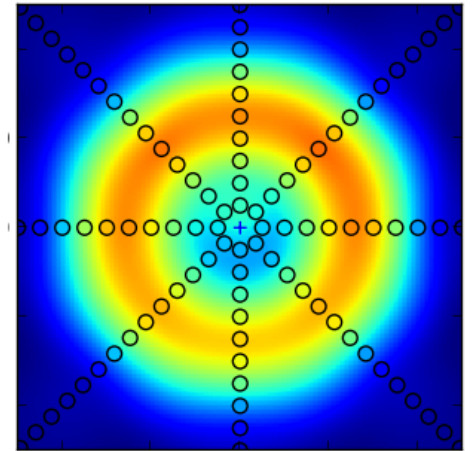


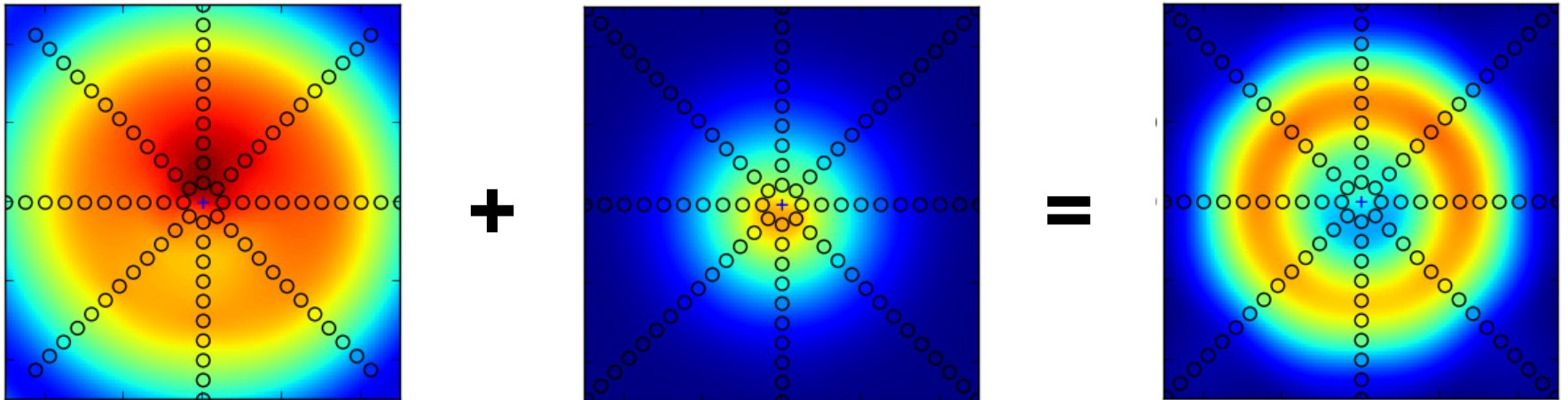
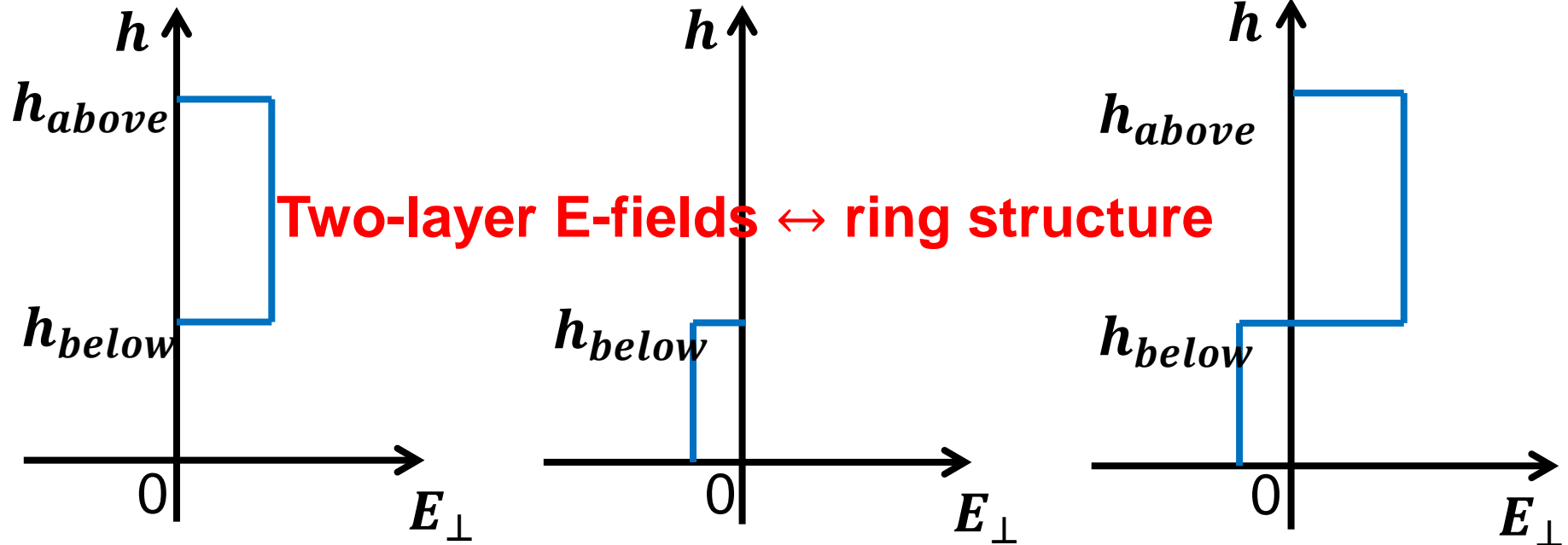


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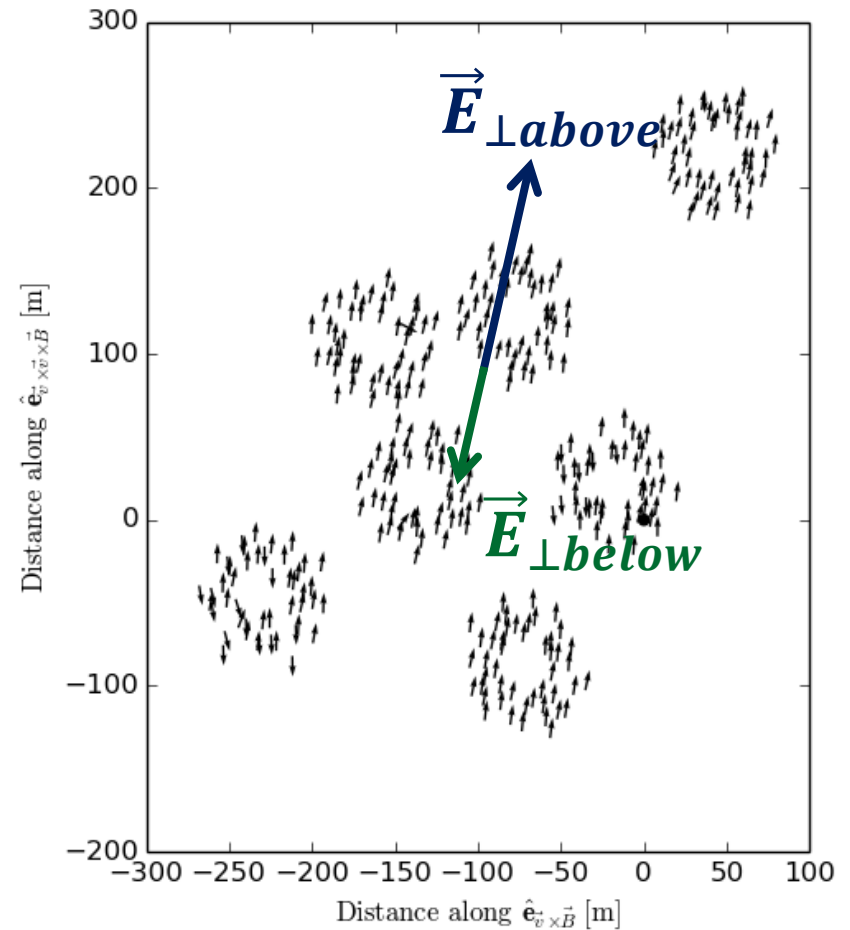
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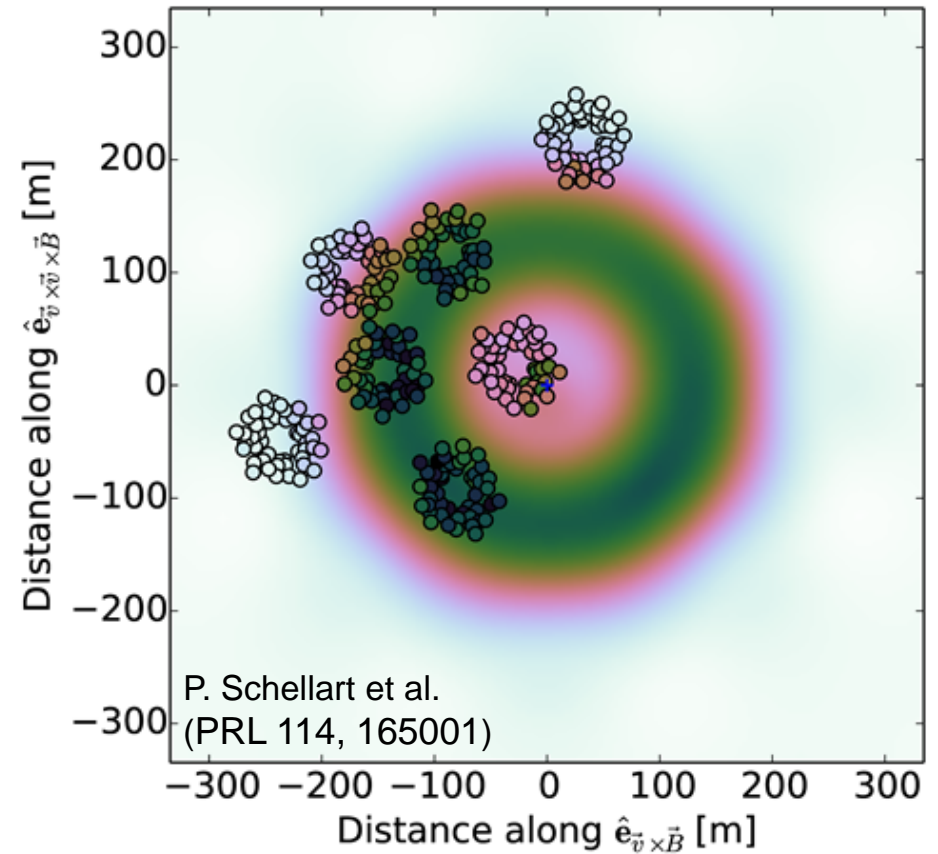
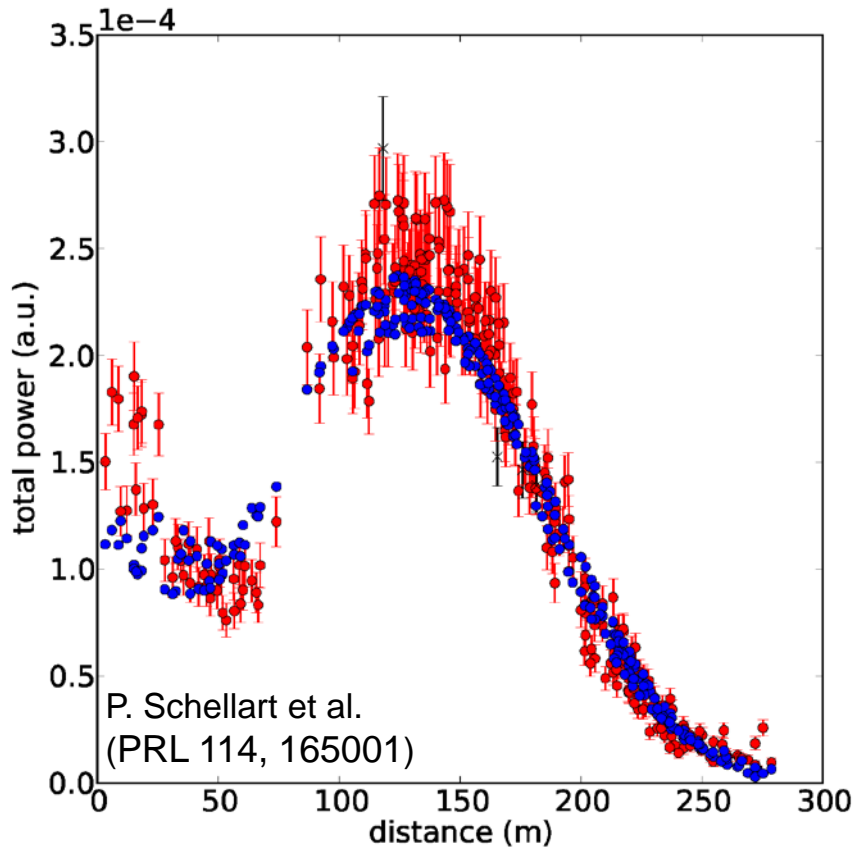


Direction of E-fields:
 determined from
 polarization patterns



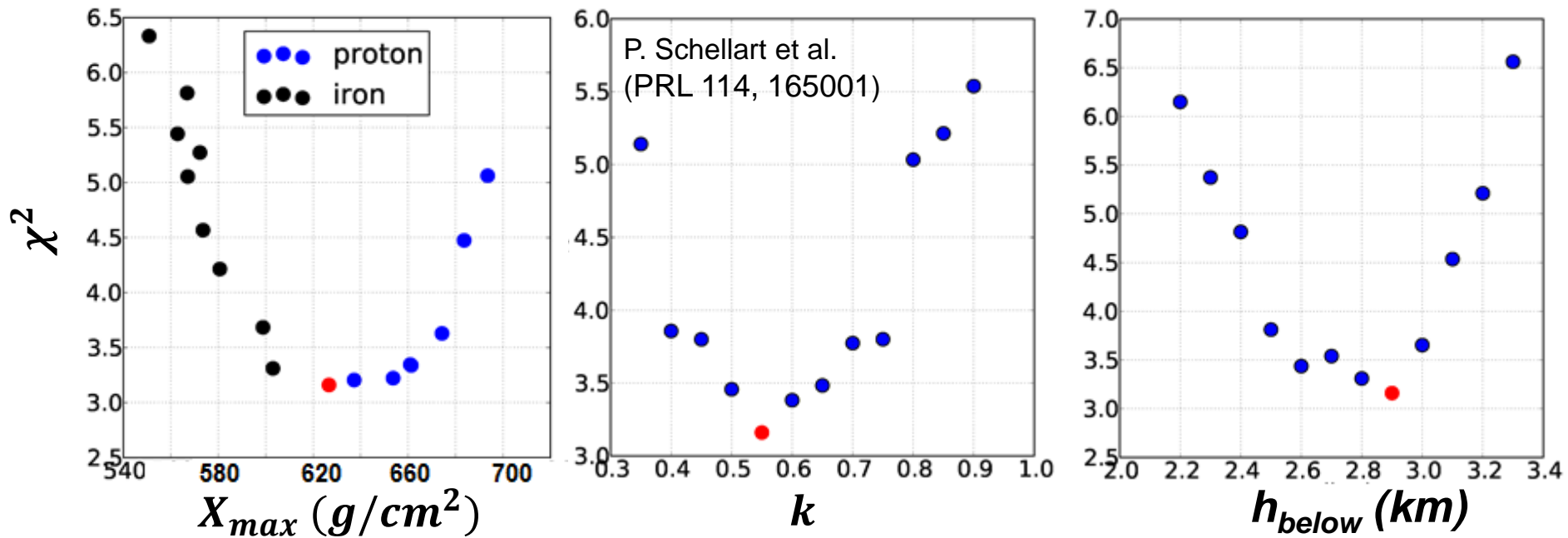


A reconstructed thunderstorm event





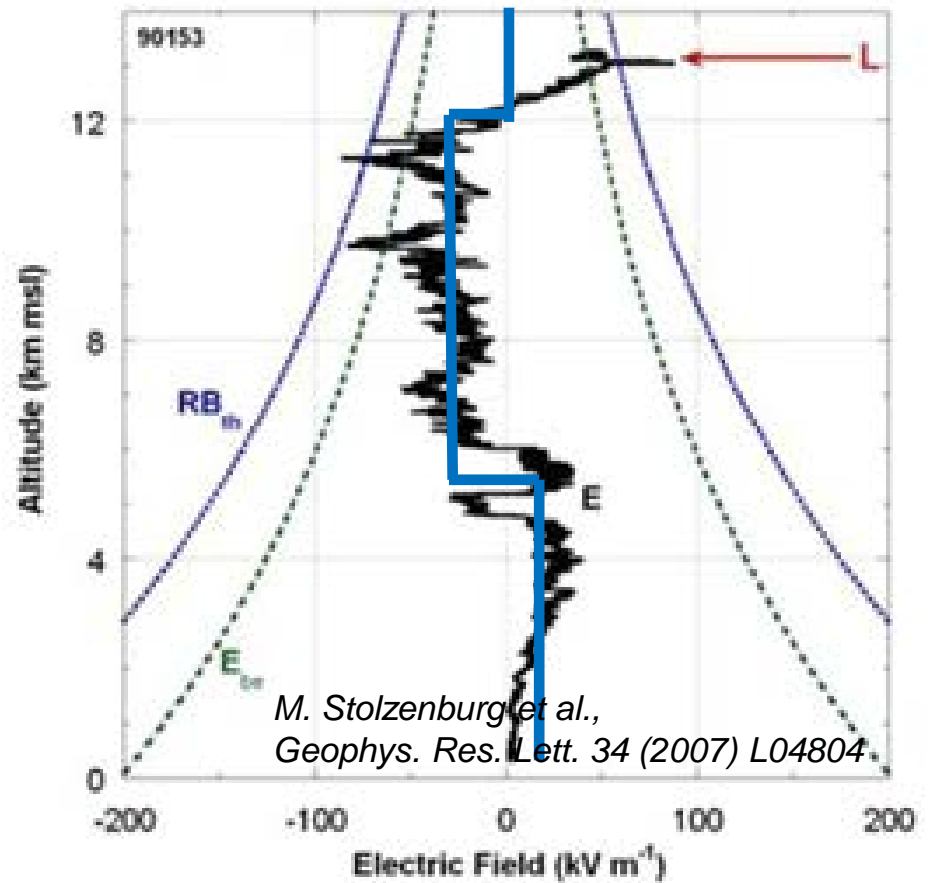
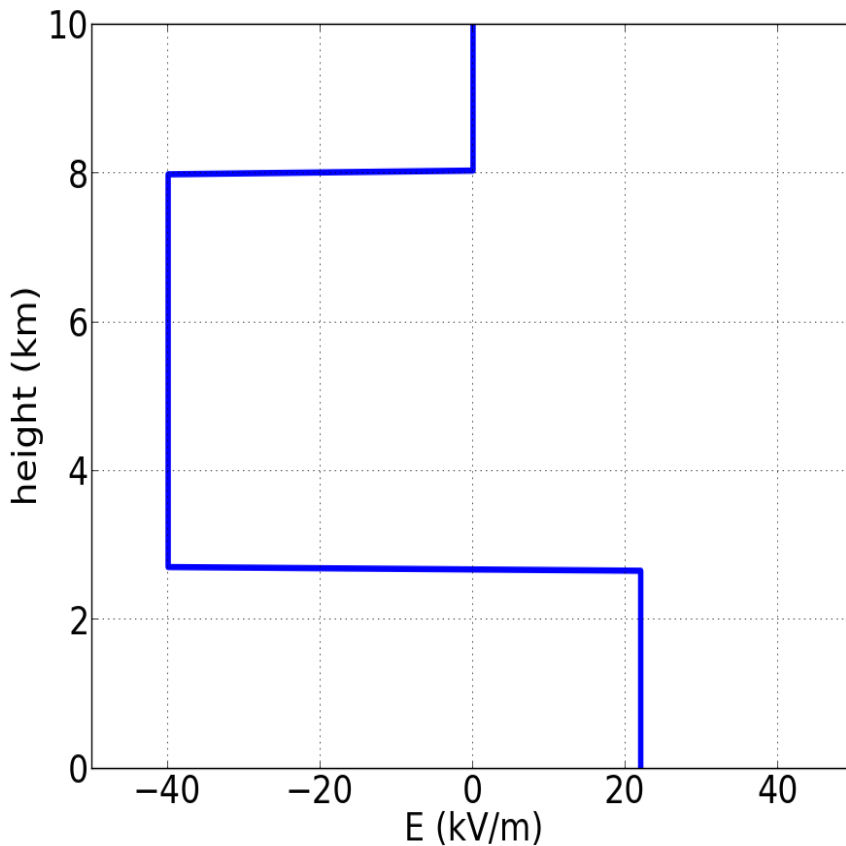
χ^2 mapping



h_{below} and k are well-defined.



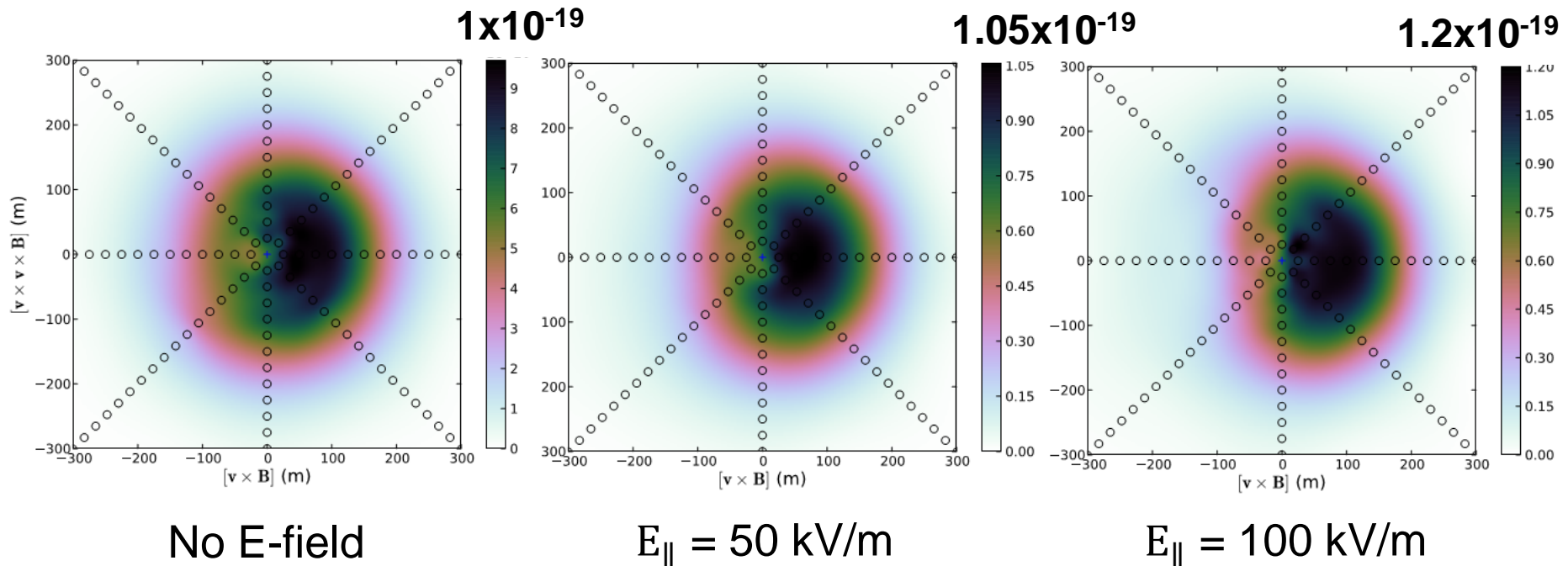
Probing effective electric fields





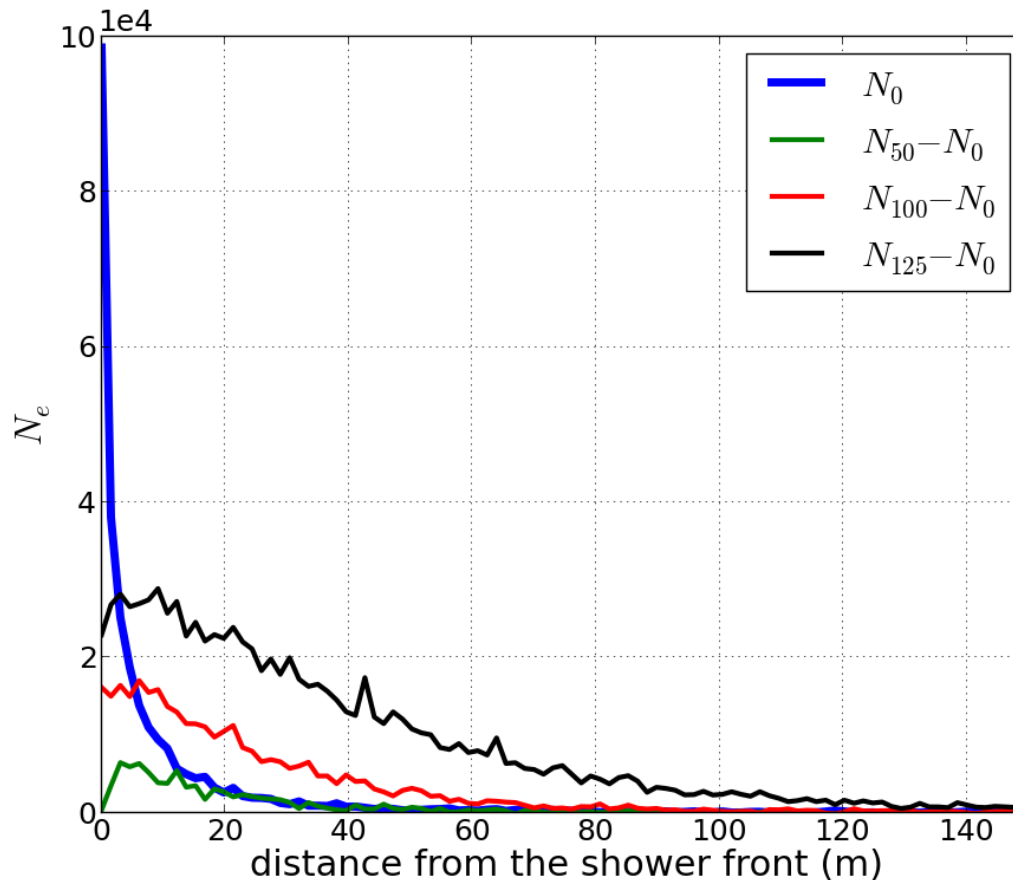
Parallel electric fields

At 30 – 80 MHz: little sensitivity to parallel electric fields





Parallel electric fields

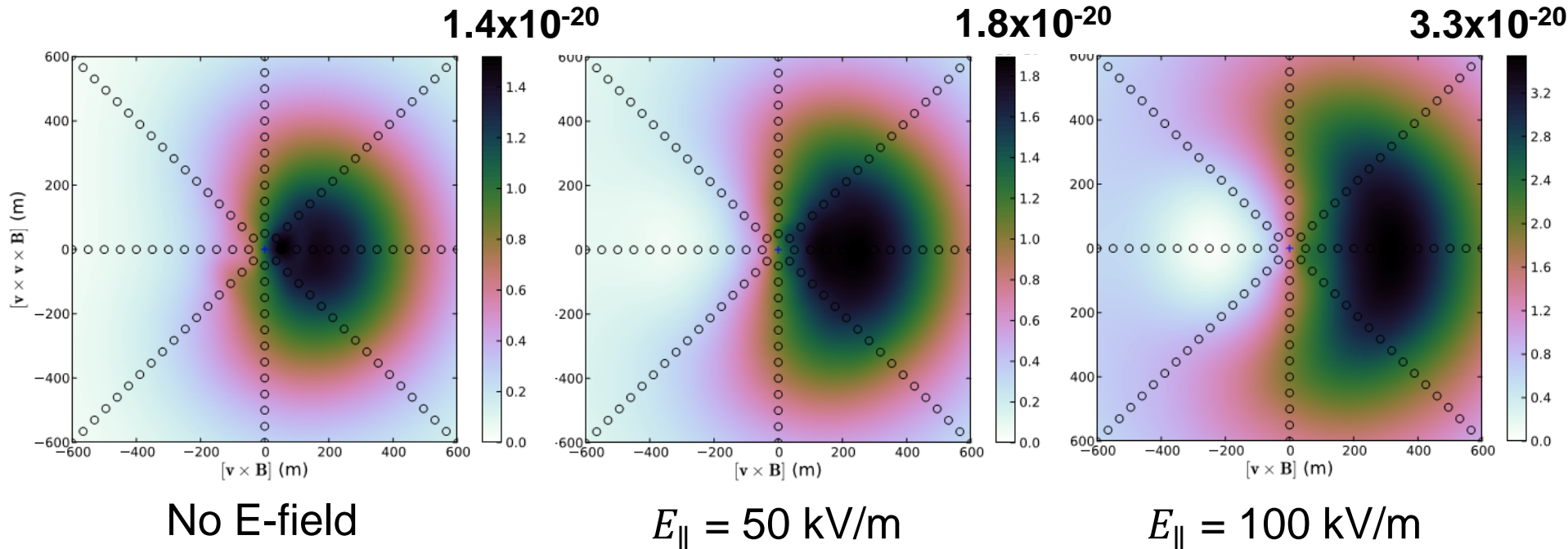


→ Enhanced electrons at large distances



Parallel electric fields

Sensitivity at lower frequencies (2 – 9 MHz)



→ Suggestion: install some low-frequency antennas



Summary and outlook

Summary:

- Understand the influence of electric fields on air showers and their radio emission
- Build a simple model reconstructing thunderstorm events successfully
- Probe electric fields in thunderstorm using LOFAR

Outlook:

- Analyze more thunderstorm events in progress

Probing Atmospheric Electric Fields in Thunderstorms through Radio Emission from Cosmic-Ray-Induced Air Showers, *P. Schellart, T.N.G. Trinh et al., Phys. Rev. Lett. 114, 165001*

Influence of Atmospheric Electric Fields on Radio Emission from Cosmic-Ray Induced Air Showers (*in preparation*)



university of
 groningen

kvi - center for advanced radiation technology

Thank you!