Tunka-Rex: the Tunka Radio Extension

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Tunka-Rex: Partners and Location

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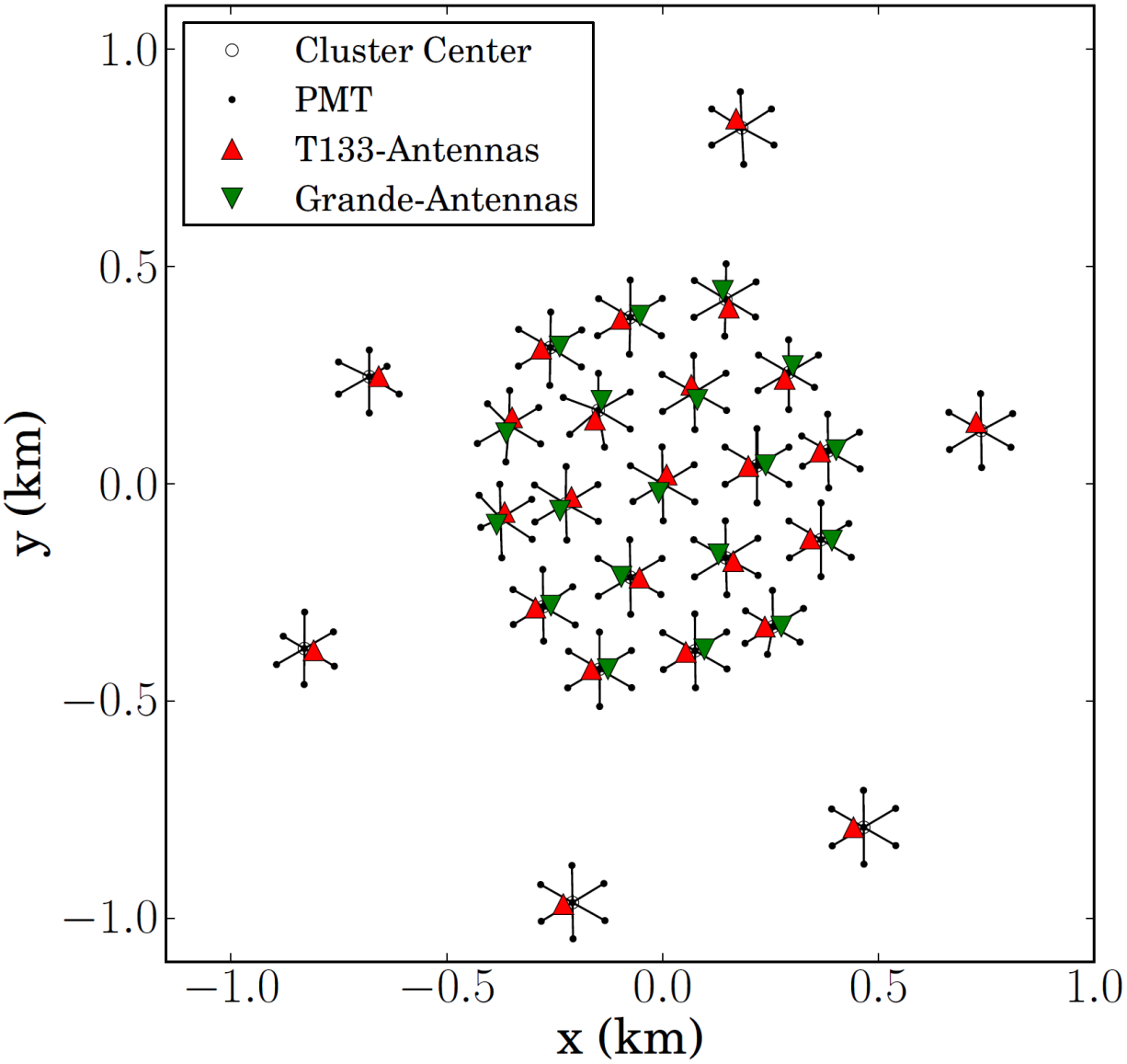
Layout of Tunka-Rex



- 25 antennas for Tunka-133
  - Started 2012
  - Trigger by PMTs
- 19 antennas for Tunka-Grande
  - Start 2014
  - Trigger by scintillators
- Array layout
  - 200 m spacing
  - 1 km² inner area

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Properties of Tunka-Rex

- Shared data-acquisition with Tunka-133 / Tunka-Grande
  - Radio antennas as slave detector (externally triggered)
  - Automatically hybrid measurements for same air-showers
  - Ideal for cross-calibration of different methods
- Economic design
  - 500 $ per antenna including all analog electronics, cables, etc.
  - Approx. 3 man-days per antenna for production and deployment
- Based on experience of other experiments
  - Usual 30-80 MHz bandwidth
  - Using known algorithms for data processing and reconstruction

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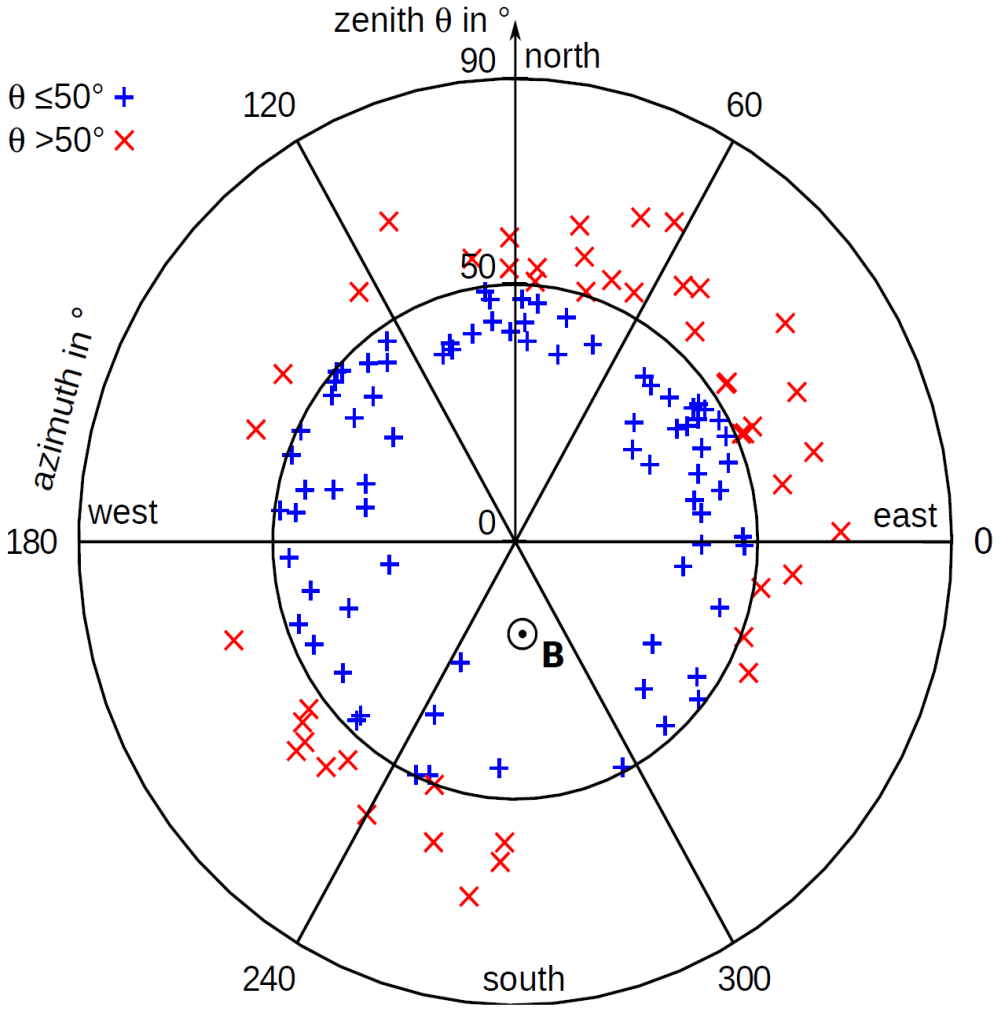
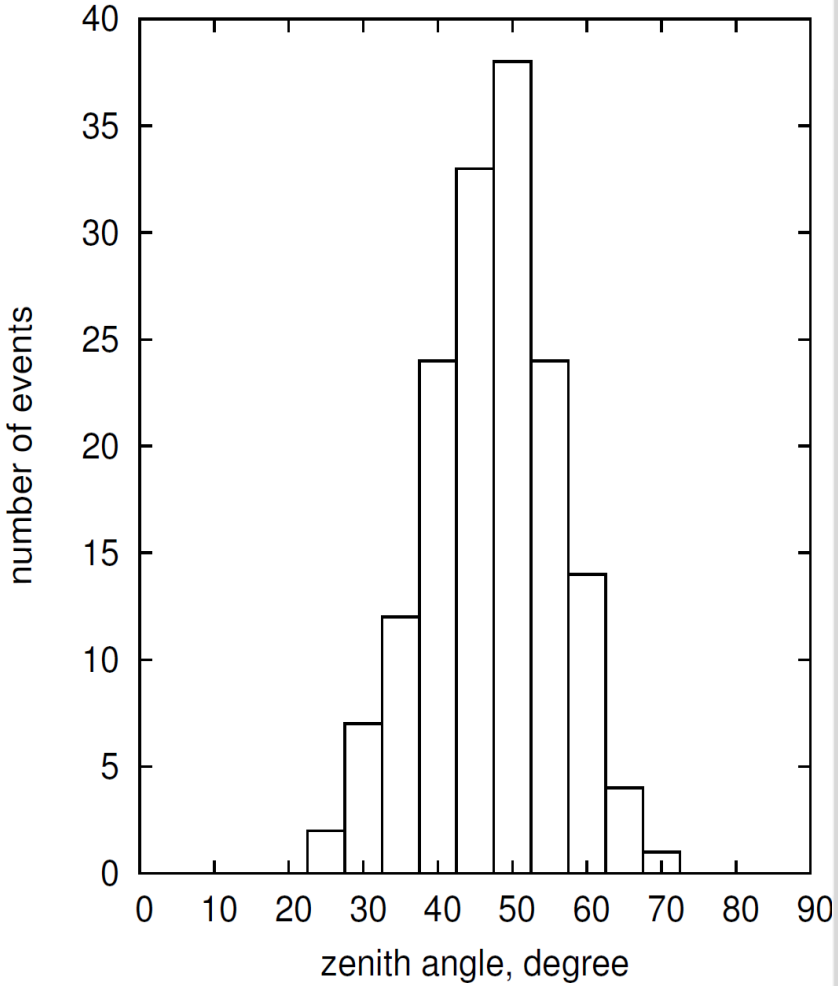
Events of first season (2012/2013)





+: 78 events x: 40 events in 450 hours

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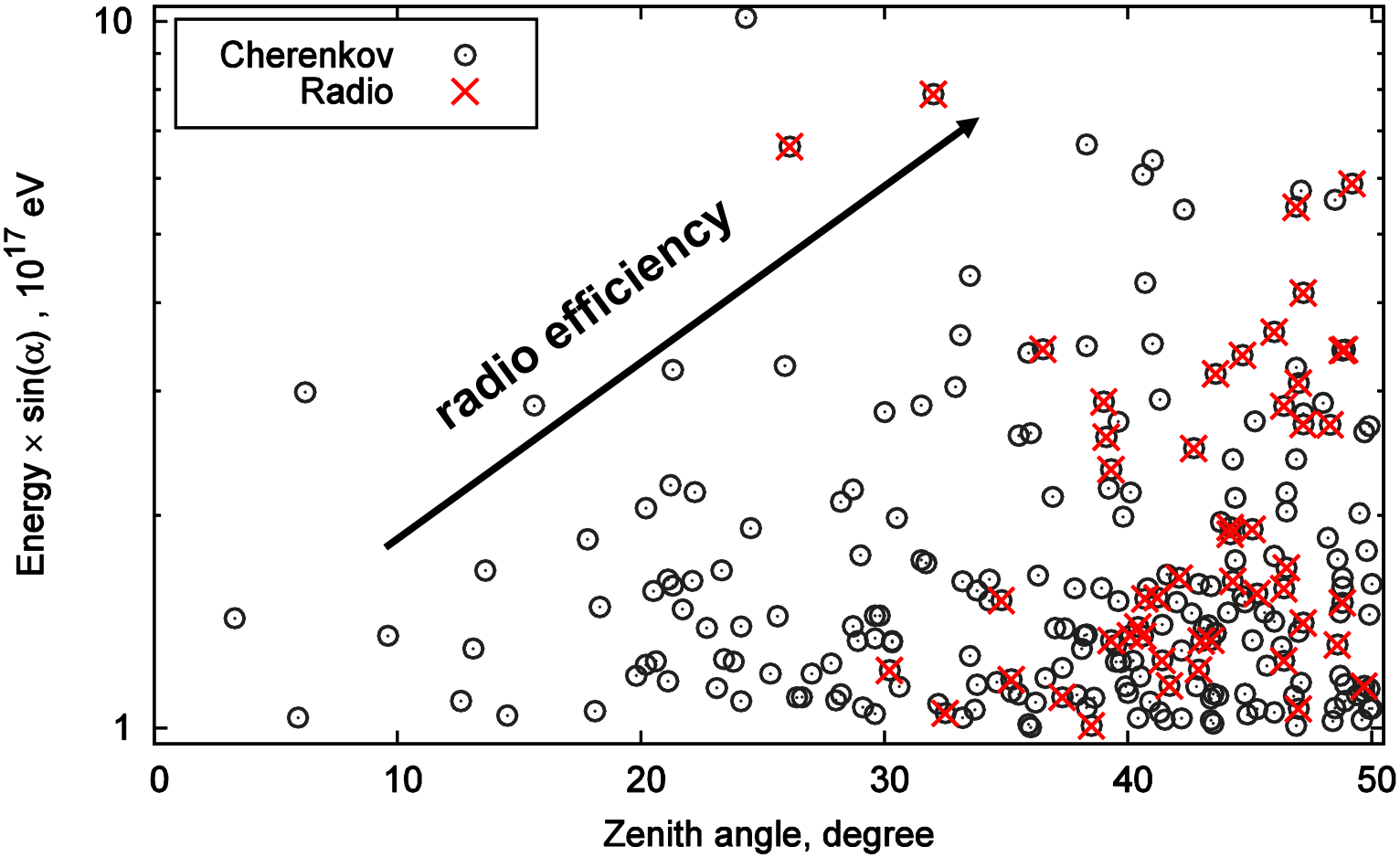
Detection efficiency

- All events with good Tunka-133 reconstruction vs. radio events with good signal in at least 3 antennas



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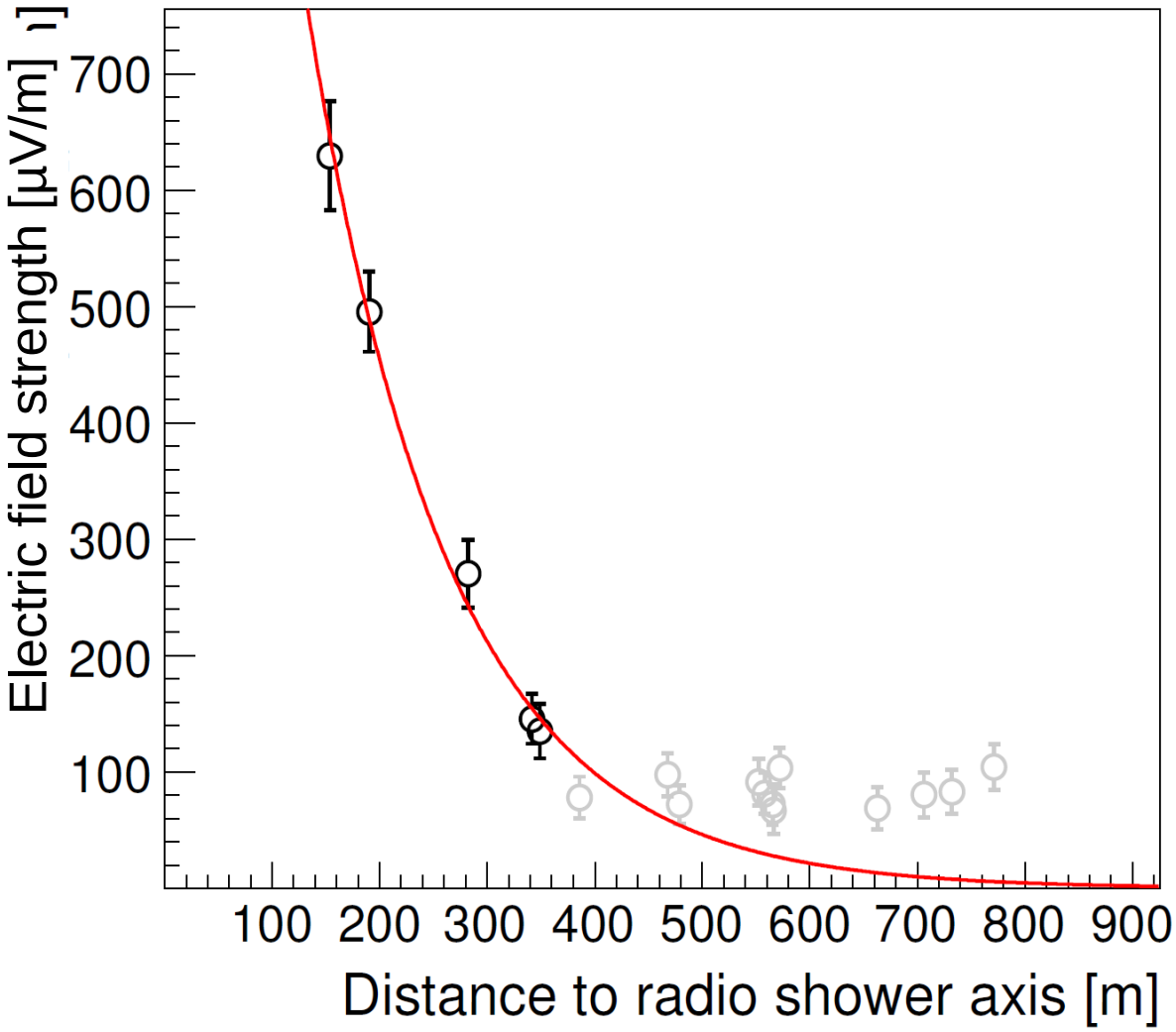
Example event: lateral distribution



- Simple exponential fit function
- Ignore:
  - Asymmetries
  - Flattening towards shower core
- Advantage
  - Requires only 3 antennas
  - Sufficient for energy reconstruction

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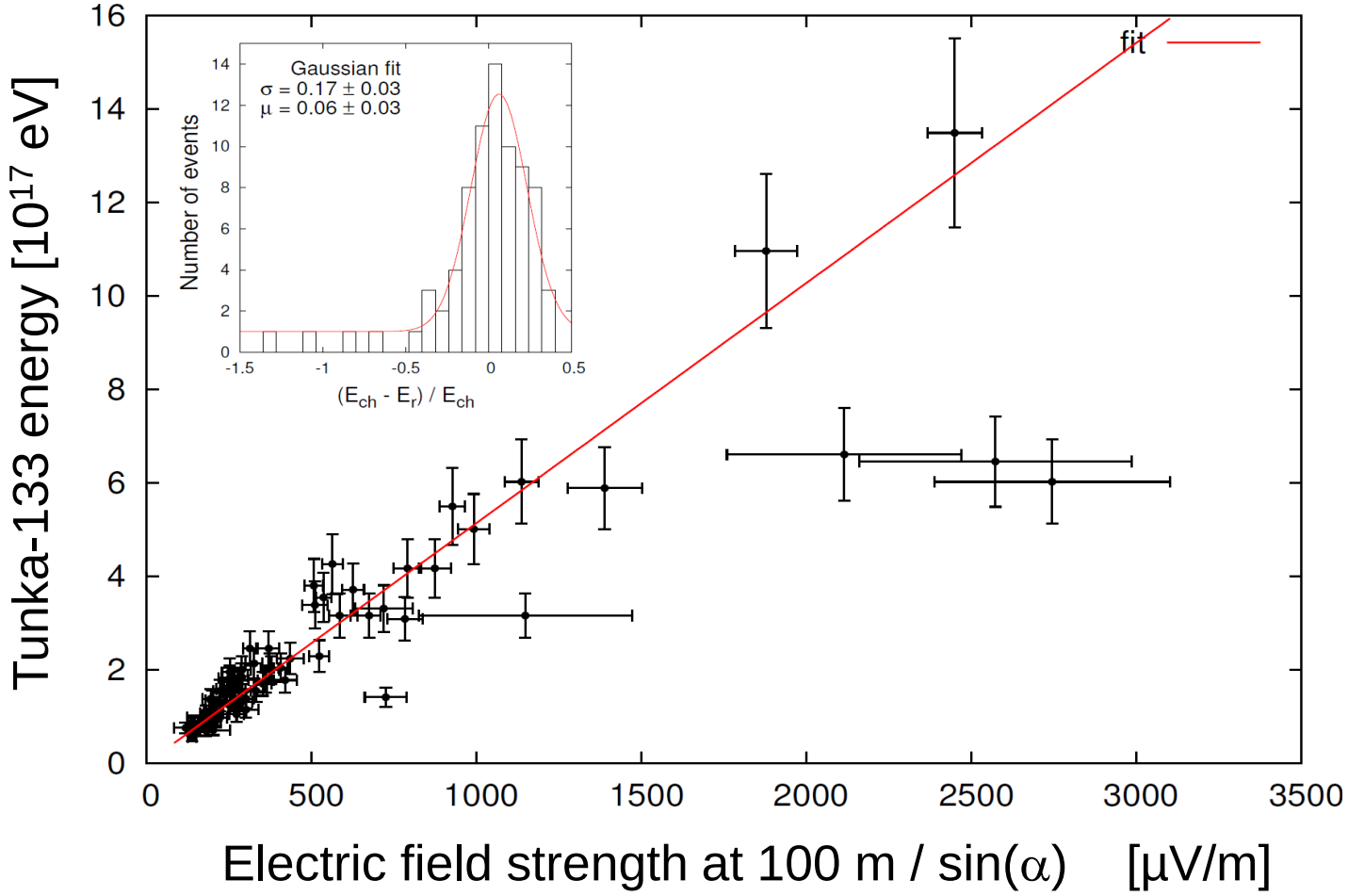
Energy reconstruction

- Energy ~ amplitude at 100 m / sin (geomagnetic angle)
- Spread corresponds to Tunka-133 precision (~ 15%)



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Next steps

- X_{max} reconstruction and cross-calibration with Tunka-133
  - Shape of lateral distribution and of wavefront
  - More complicated, maybe more antennas necessary
- Semi-blind analysis to experimentally determine precision
  - Radio reconstruction tuned to Tunka-133 data of 2012/2013
  - But energy and X_{max} of Tunka-133 blind for season 2013/2014
  - Will be revealed only after radio prediction for energy and X_{max}
- Cosmic-ray physics with scintillator trigger
  - 10 times higher statistics for the last energy bins around 10^{18} eV

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Conclusion

- Tunka-Rex
  - Economic radio extension for Tunka-133 and Tunka-Grande
- Scientific Goals
  - Cross-calibration with air-Cherenkov measurements
  - Determine radio precision for energy and X_{max}
  - Hybrid measurements with scintillators can increase accuracy
- TAIGA-Rex
  - Tunka-Rex concept scaled to 10 km²
  - Radio brings additional benefits ~ 10^{18} eV for low additional costs

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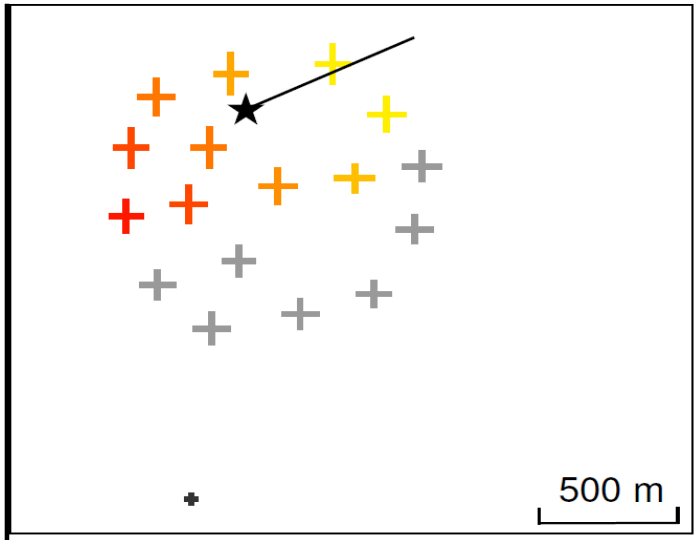
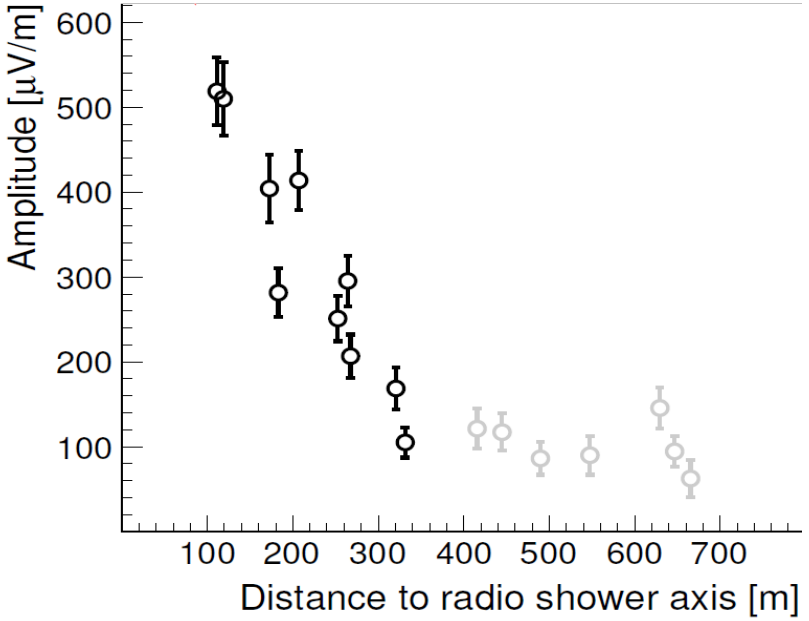
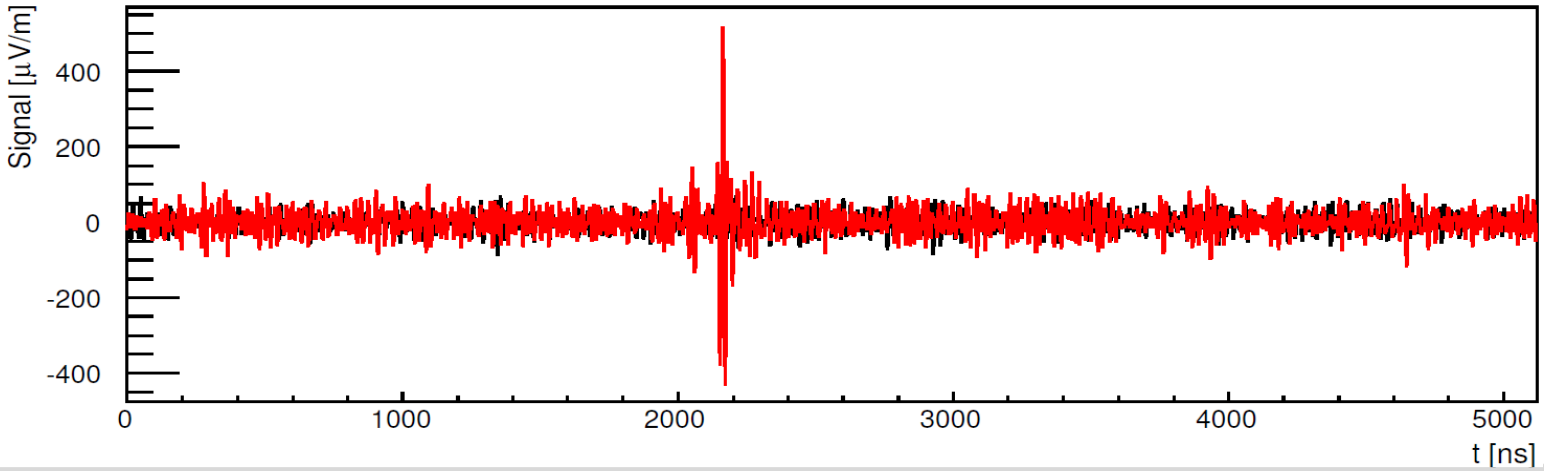
Example event







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Technical Data

	Tunka-Rex
Trigger and DAQ	Tunka-133 / Tunka-Grande
Antennas: number **type**	44 (2 channels each) SALLA
Alignment	NW-SE and NE-SW
Spacing	~ 200 m
Area	1 km² + outer stations
Frequency band	30 – 80 MHz
Sampling: rate **trace length**	200 MHz 1024 samples (≈ 5 µs)
Approx. cost per antenna	~ 500 $
Analysis software	Offline (with kind permission by the Pierre Auger Collaboration)
Energy range	> 10^{17} eV

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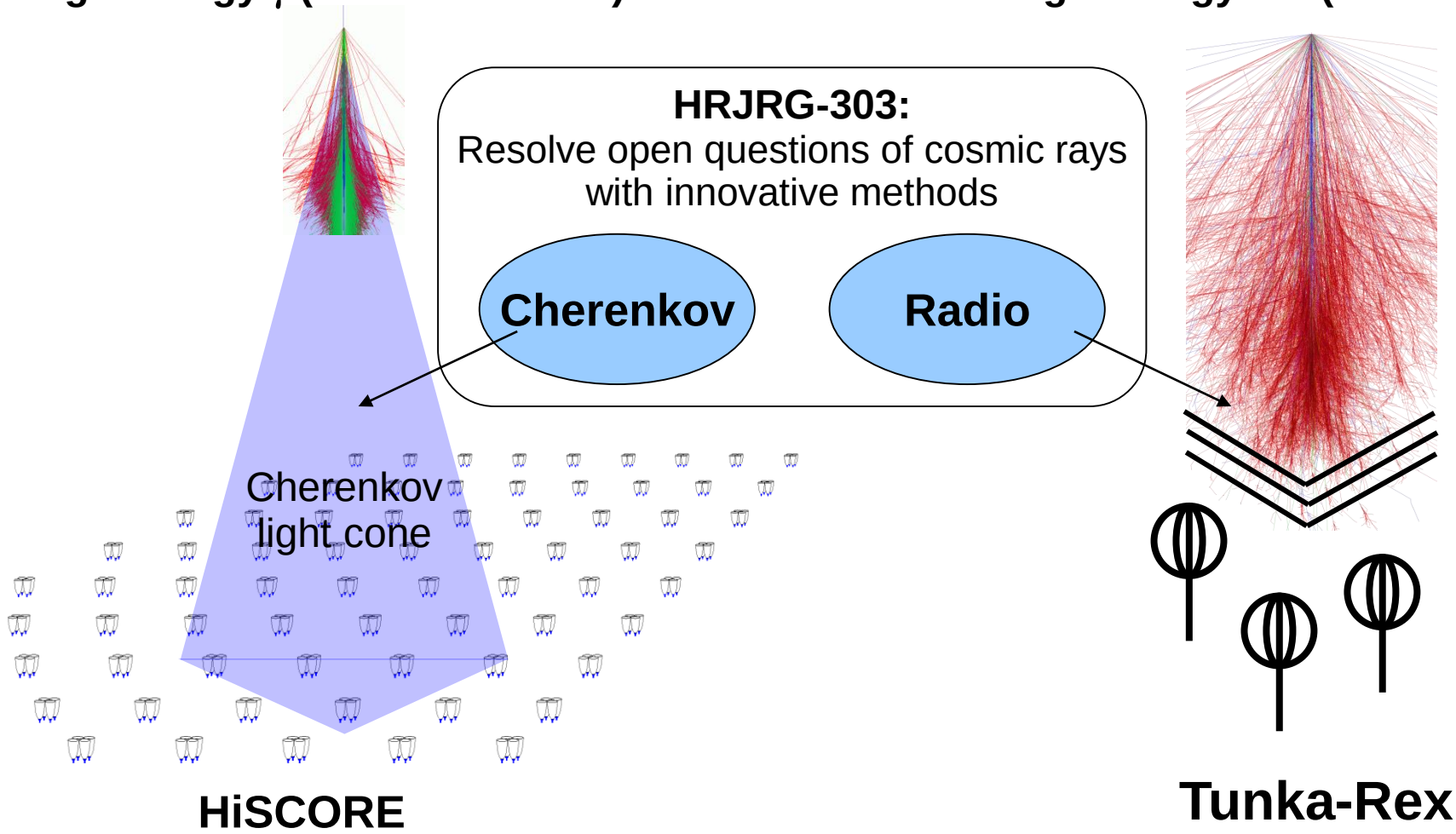
High energy γ (GeV / TeV / PeV):

Ultra-high energy CR (PeV - EeV):



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