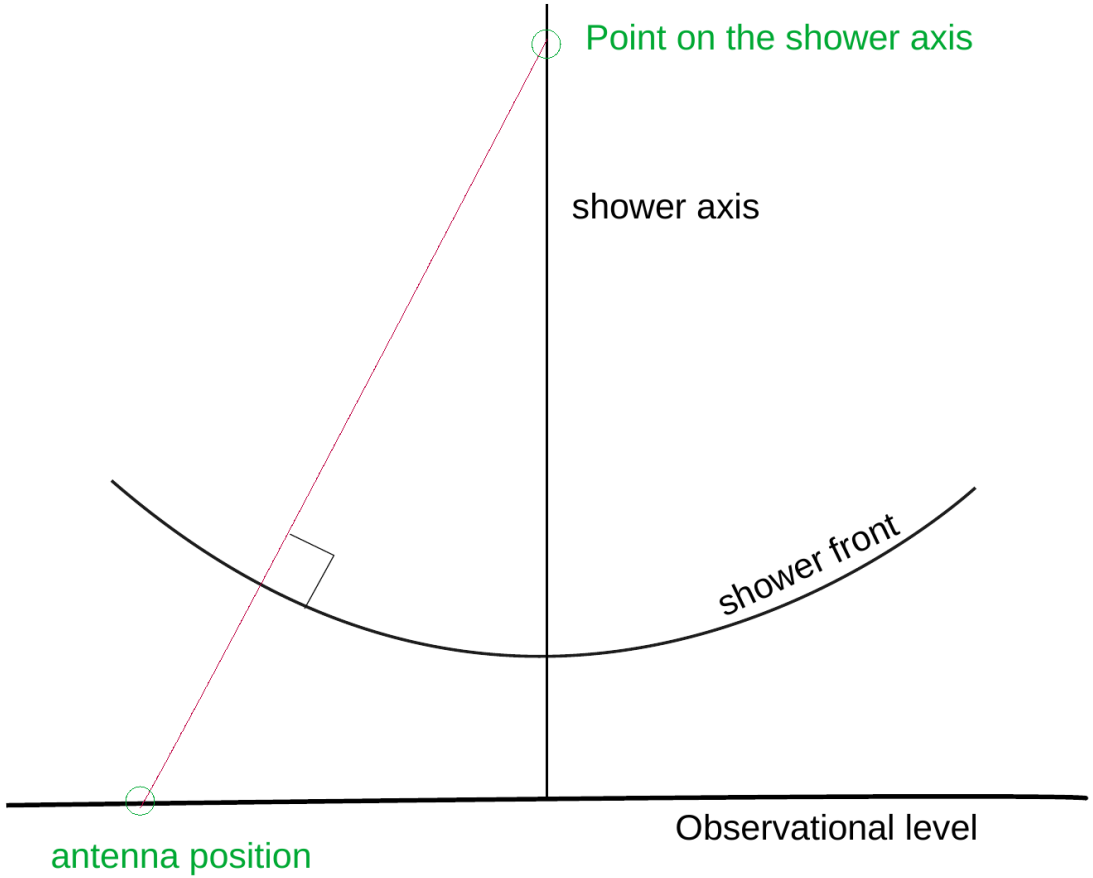
Reconstruction of X_{max} based on backtracking of radio signals

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June 27, 2023

Reconstruction of X_{max} (Overview)



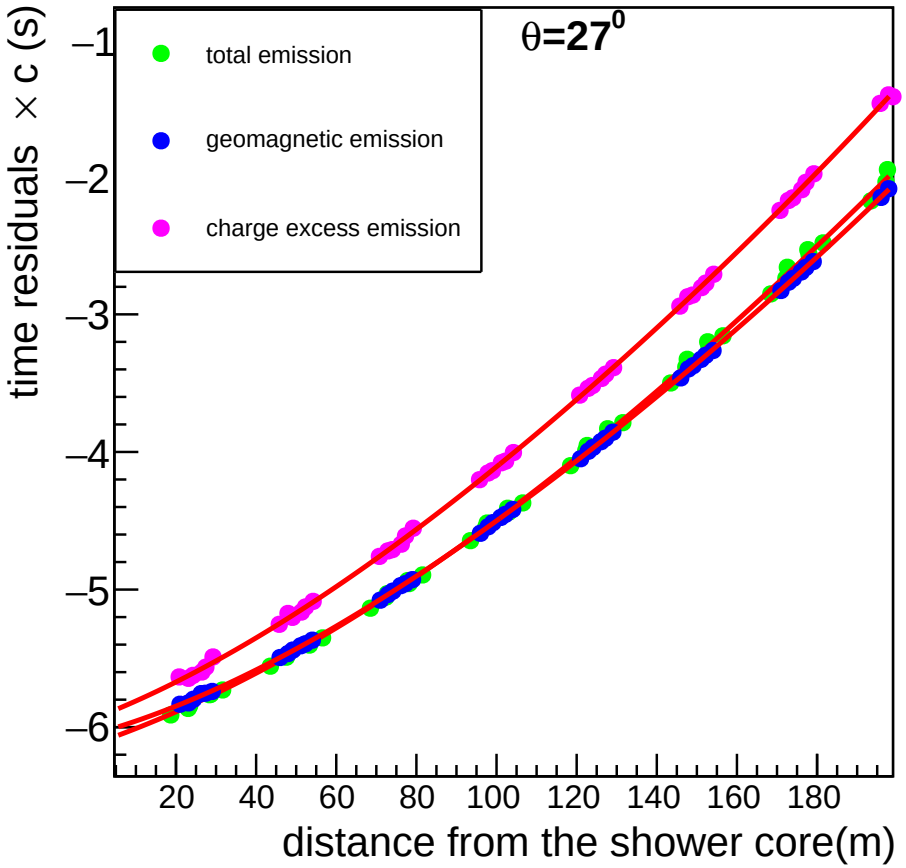
- associate each antenna with a point on the shower axis
- backtrack the signal - signal travels perpendicular to the shower front
- construct a longitudinal profile from the signal
- obtain X_{max} from this longitudinal profile

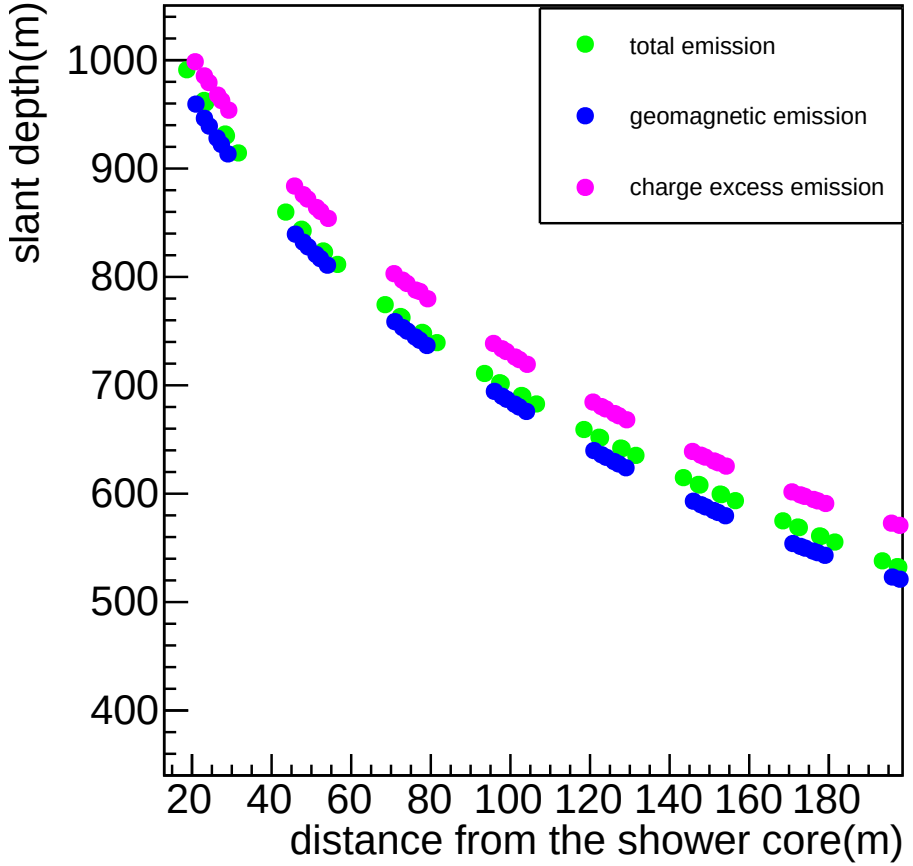
- star shaped antenna array
- circular ring of 200 m radius in the shower plane ($\sim$ 60 antennas)
- frequency window of the antenna: 20-80 MHz
- the timing resolution is 0.1 ns
- shower cores are at(0,0)

- geomagnetic emission is $\mathrm{V} \times \mathrm{B}$ polarized
- charge excess emission is polarized radially inwards towards the shower axis
- $\mathrm{E}_{\mathrm{geo}}(\mathrm{r}, \mathrm{t}) = \mathrm{E}_{\mathrm{V}\times\mathrm{B}}(\mathrm{r}, \mathrm{t}) - \frac{\cos(\phi)}{\sin(\phi)} \mathrm{E}_{\mathrm{V}\times\mathrm{V}\times\mathrm{B}}(\mathrm{r}, \mathrm{t})$
- $\mathrm{E}_{\mathrm{ce}}(\mathrm{r}, \mathrm{t}) = \frac{\mathrm{E}_{\mathrm{V}\times\mathrm{V}\times\mathrm{B}}}{\sin(\phi)}$
  - ϕ is the polar angle in $\mathrm{V} \times \mathrm{B}$-$\mathrm{V} \times \mathrm{V} \times \mathrm{B}$ plane

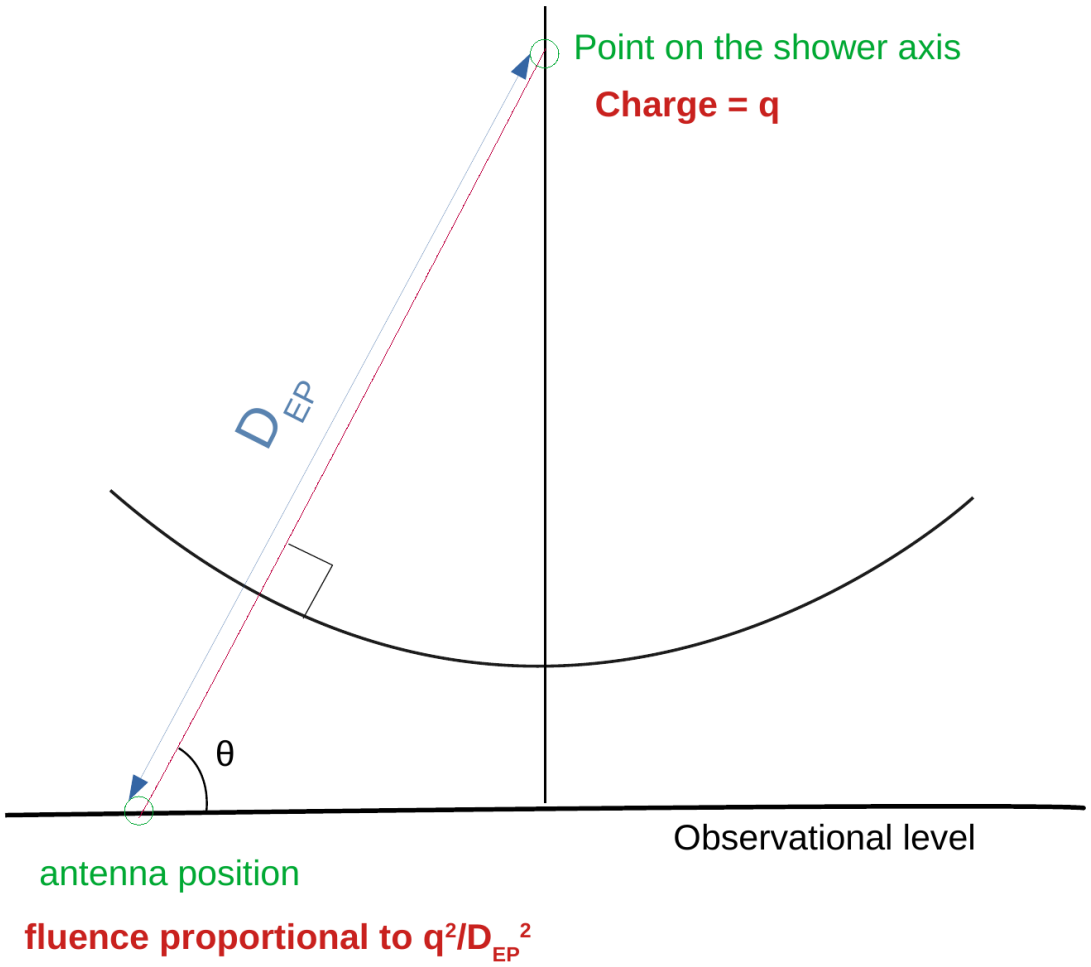
Reference: Christian Glaser et al. “An analytic description of the radio emission of air showers based on its emission mechanisms”. In: Astropart. Phys. 104 (2019), pp. 64–77.

The geomagnetic and charge excess wavefront

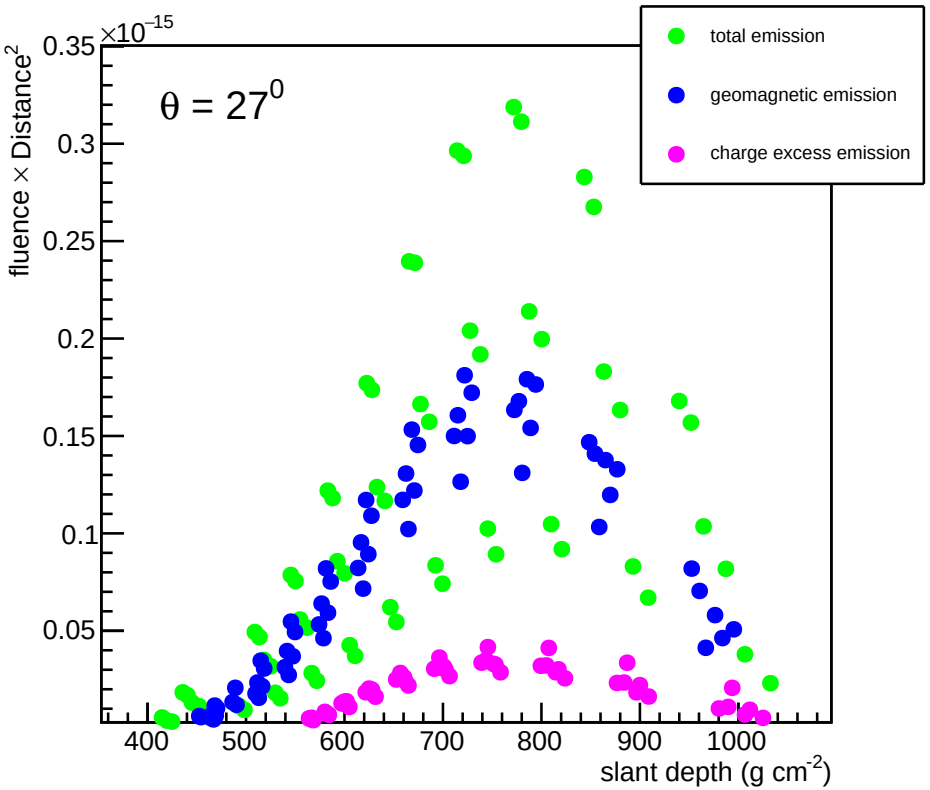


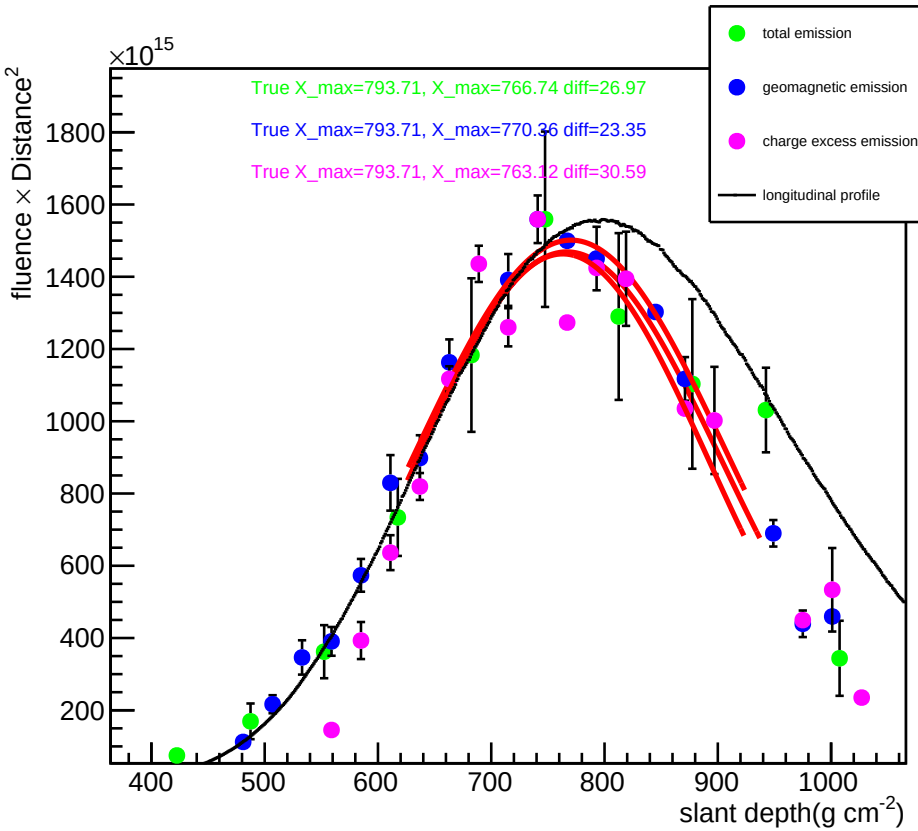


Reconstruction of the longitudinal profile

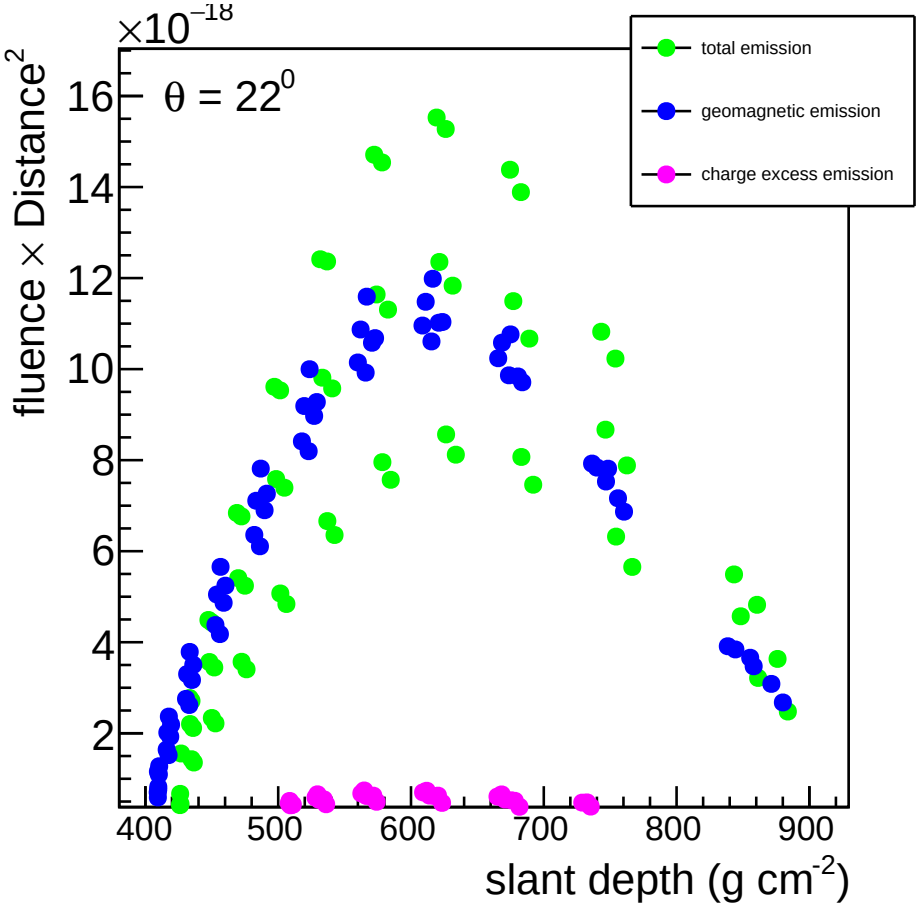


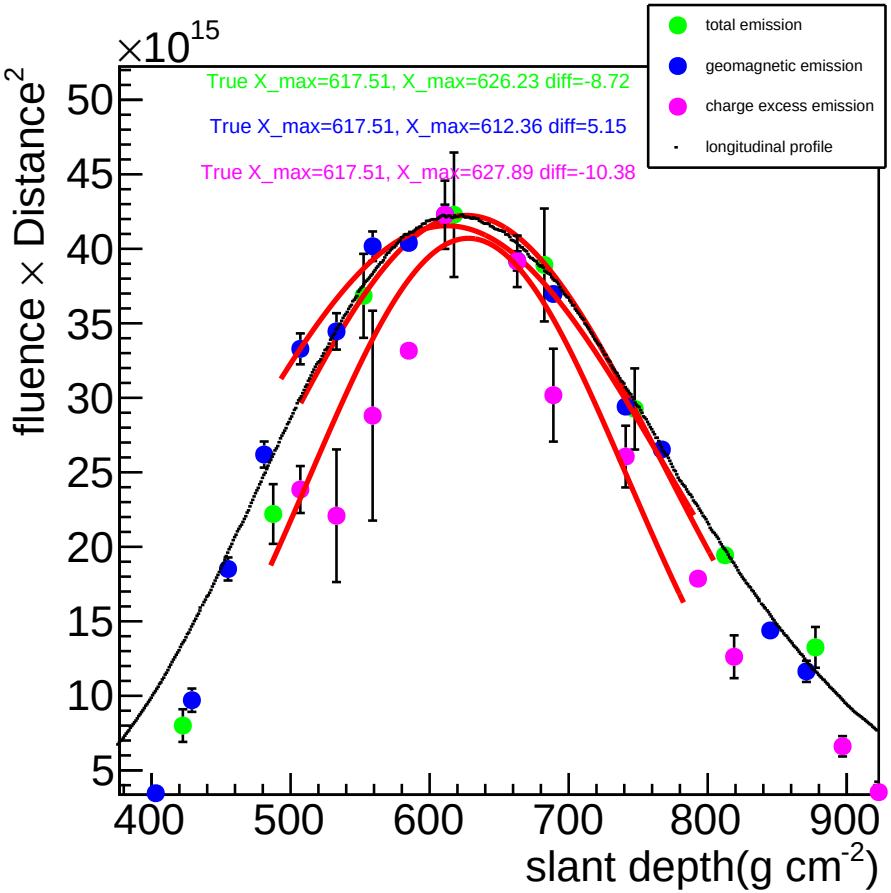
Reconstructed longitudinal profile



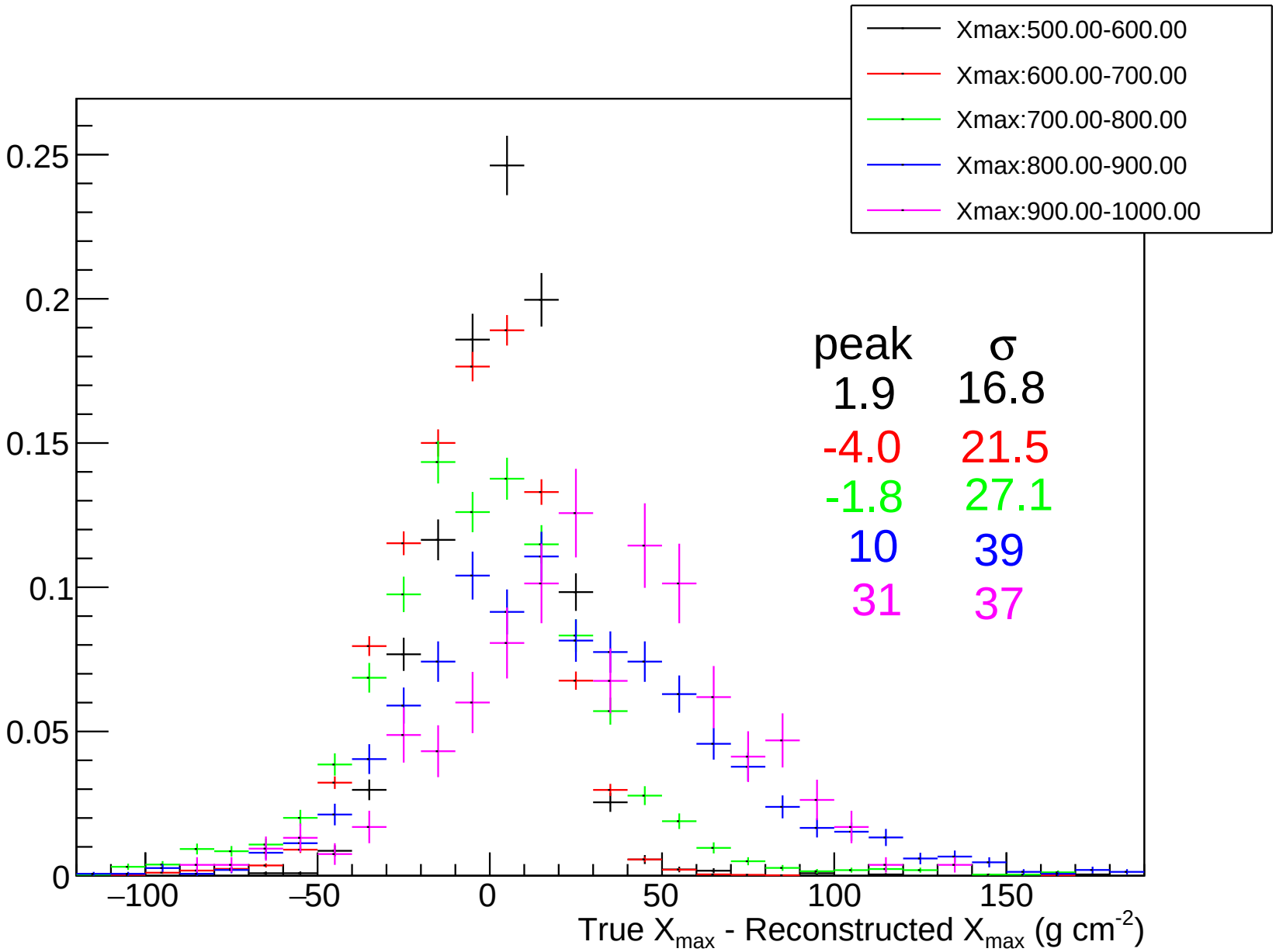


Reconstructed longitudinal profile

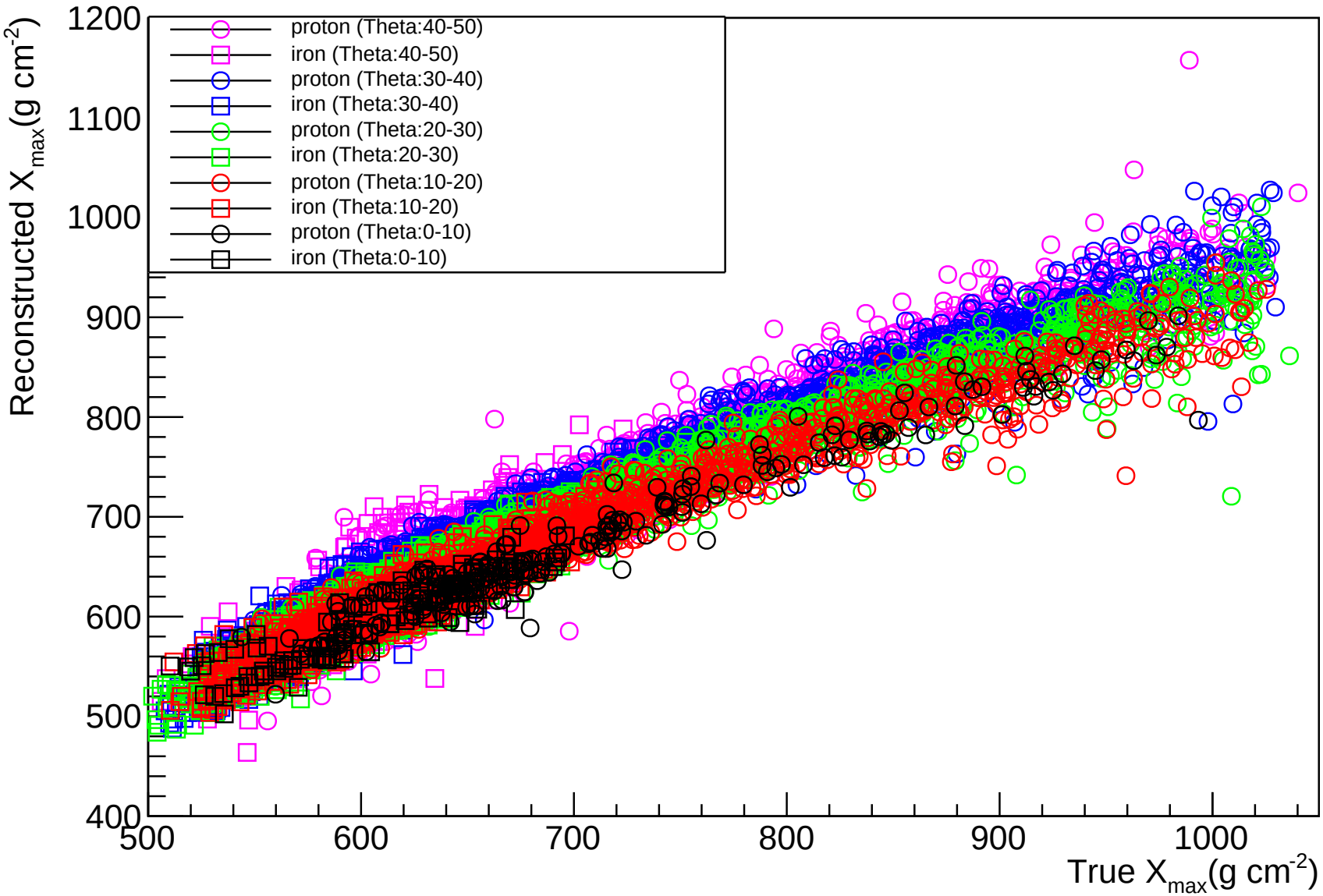




Distribution of X_{max} difference



Reconstructed X_{max} vs true X_{max}



Some corrections to be done

- use the GDAS parameters for converting height into slant depth
- check for duplicate events in the simulations
- Example: /vol/astro7/lofar/sim/pipeline/events/45616753/1/coreas/proton and /vol/astro7/lofar/sim/pipeline/events/45616753/2/coreas/proton

- Different array configuration
  - Size of the array? (Larger size enables the reconstruction of some showers which do not get properly reconstructed otherwise)
  - Antenna spacing?
- Impact of noise