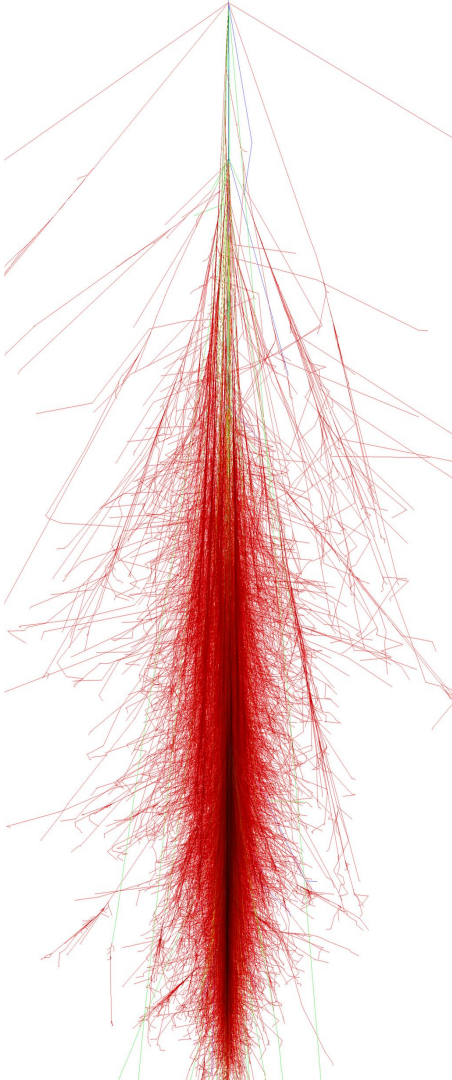
27.06.2023

Study the Xmax sensitivity wrt pulse shape (50-350MHz)

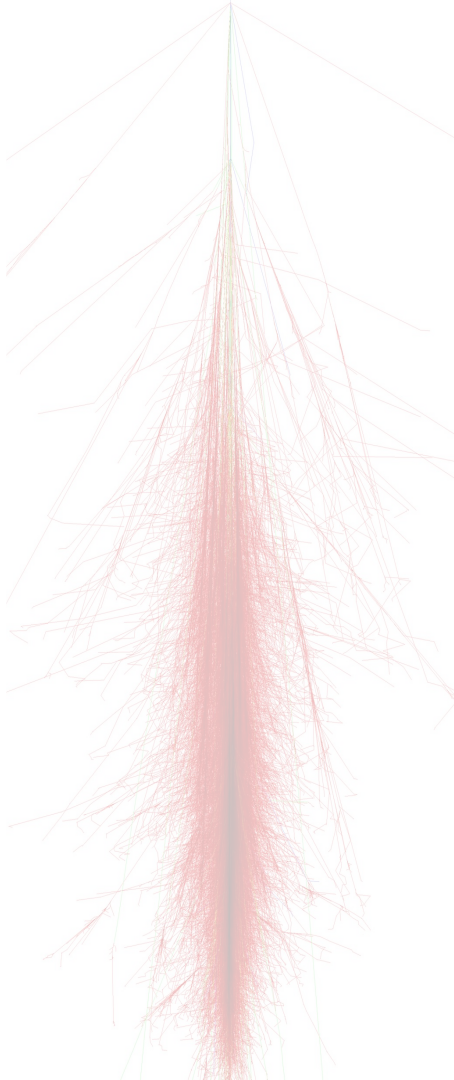
Nikos Karastathis



Karlsruher Institut für Technologie

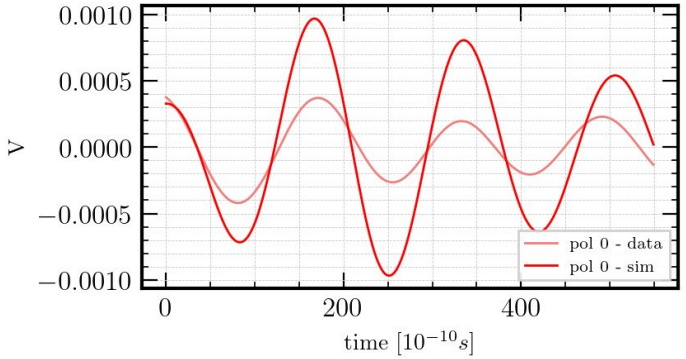
Outline

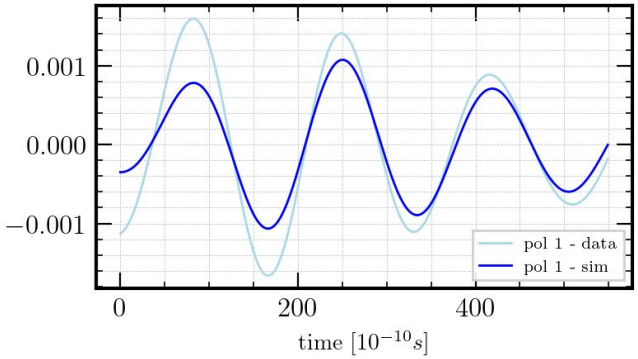
1. Antenna diagnostics (?)
2. Xmax study in time domain
3. Xmax study in frequency domain
4. Benchmarking the frequency domain study

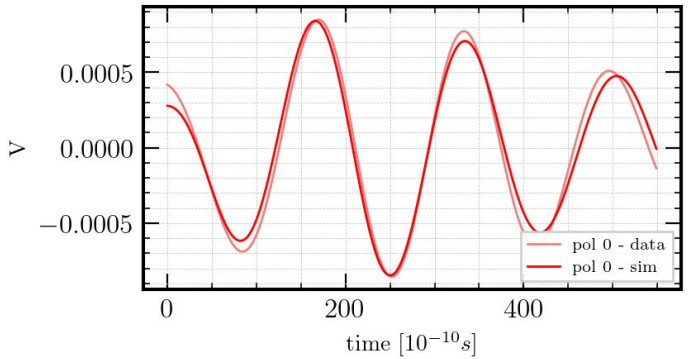


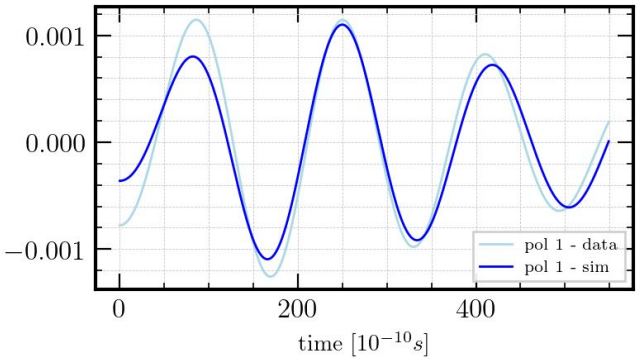
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Using the correlation factor for antenna diagnostics – real data vs sims + antenna model



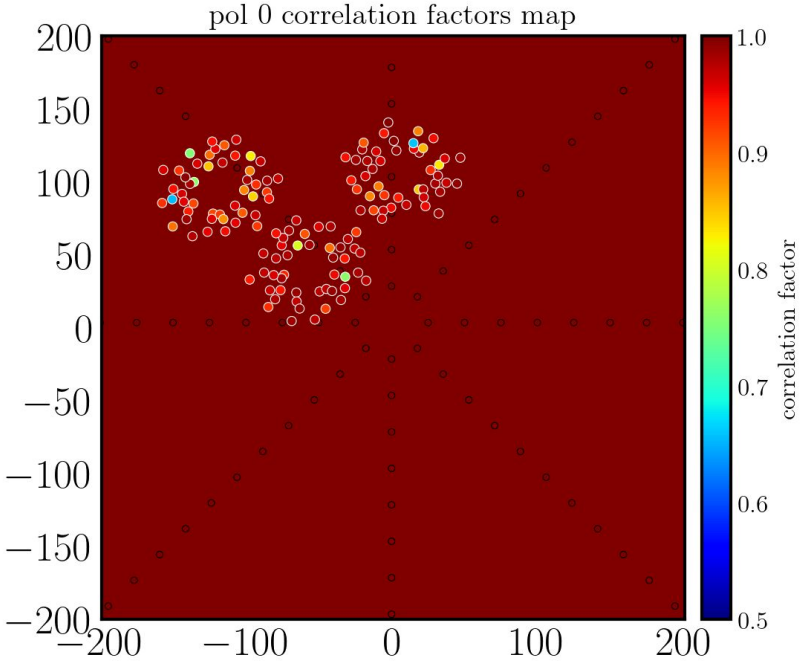


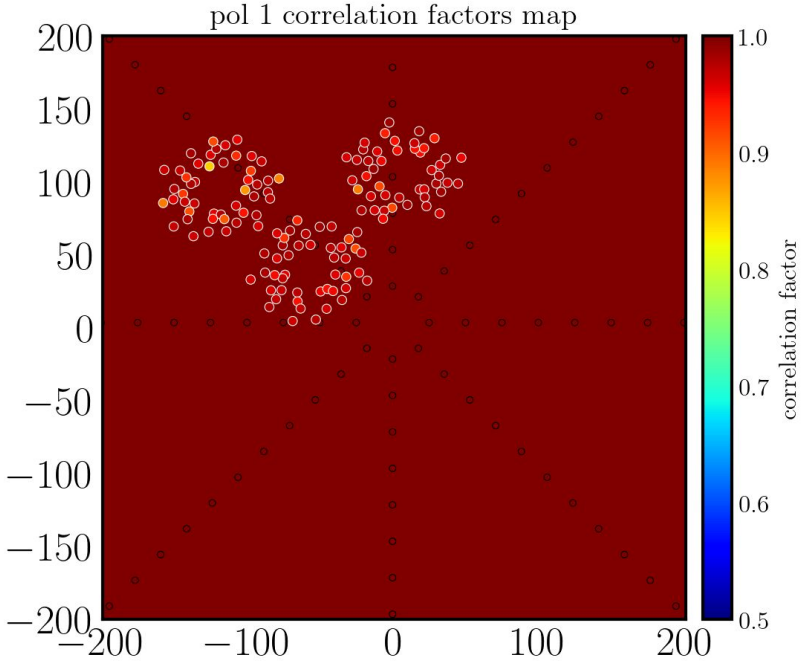




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Using the correlation factor for antenna diagnostics – real data vs sims + antenna model



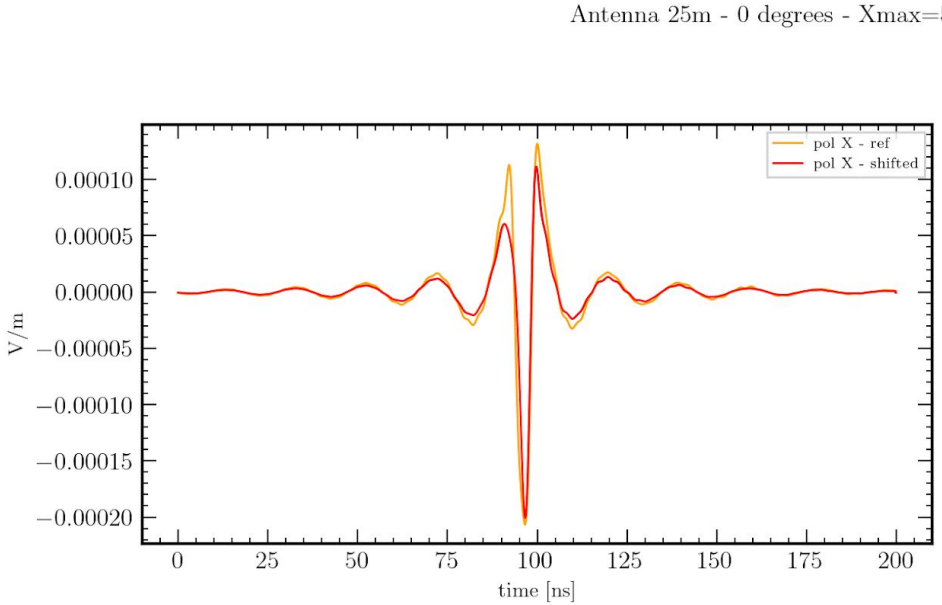


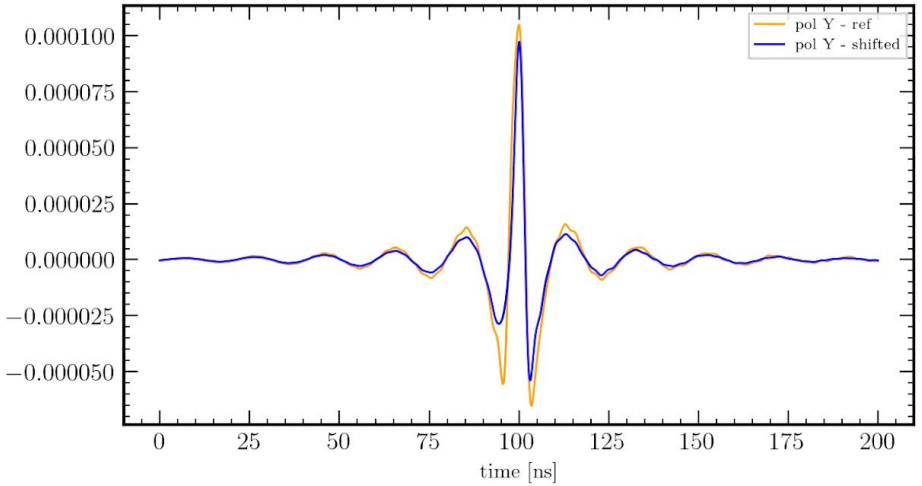
Using the correlation factor to find, compare pulses and Xmax reconstruction

1. Take several starshape simulations which differ only in Xmax and treat one as “data” reference.
2. Study the pulses for every antenna separately.
3. Slide the pulses in the time axis and match according to the highest correlation value.
4. Use Pearson correlation coefficient to correlate using the pulse shape and not the amplitude.
5. I get correlation factors for every antenna where Xmax is different.
6. Sum up all antennas (and pols) with the same Xmax and produce one final plot for the comparison.



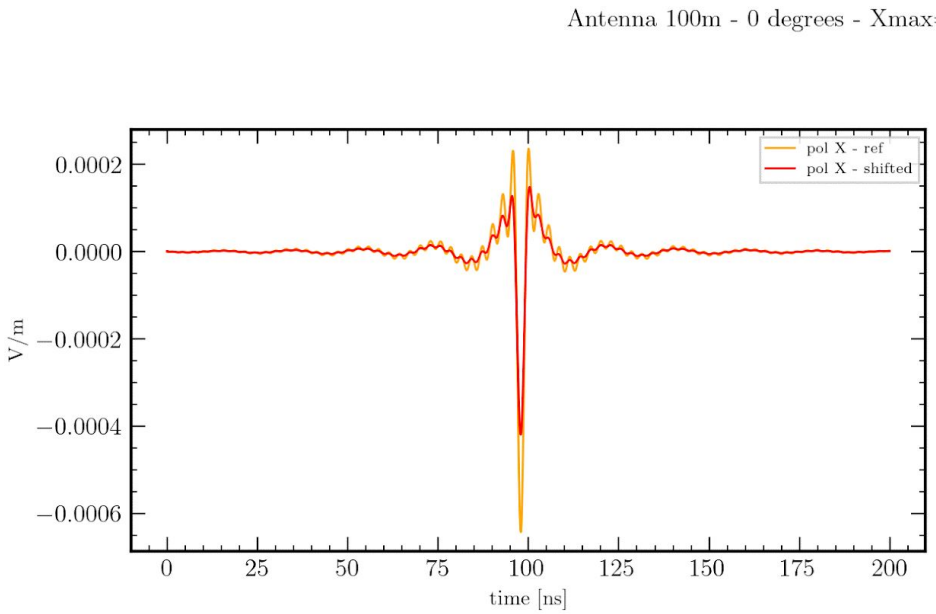
Using the correlation factor to find and compare pulses

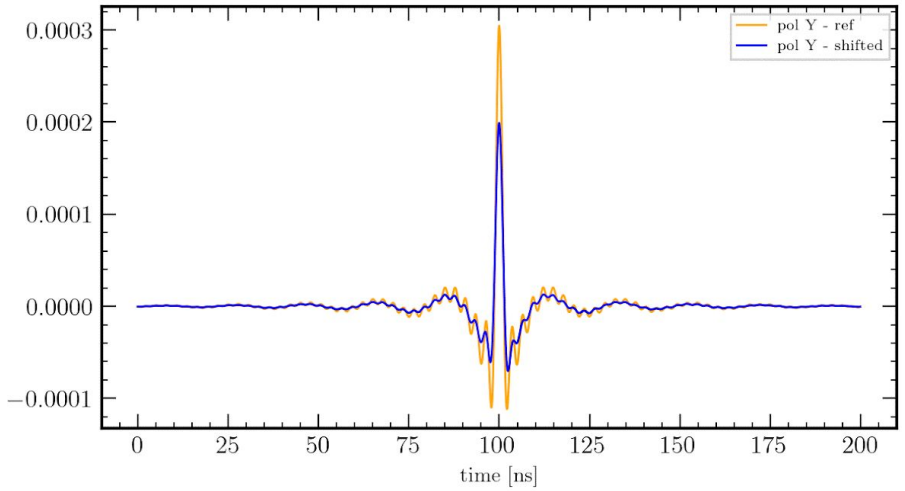




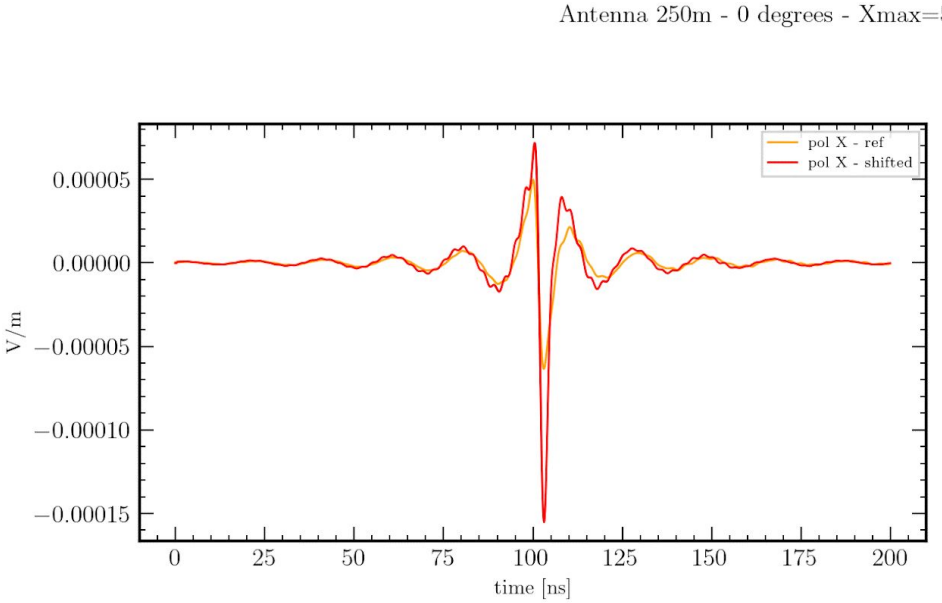
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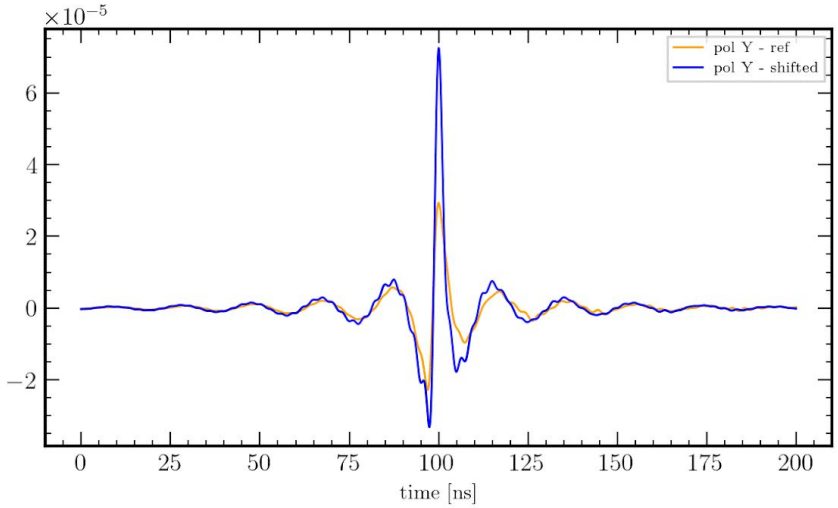
Using the correlation factor to find and compare pulses





Using the correlation factor to find and compare pulses





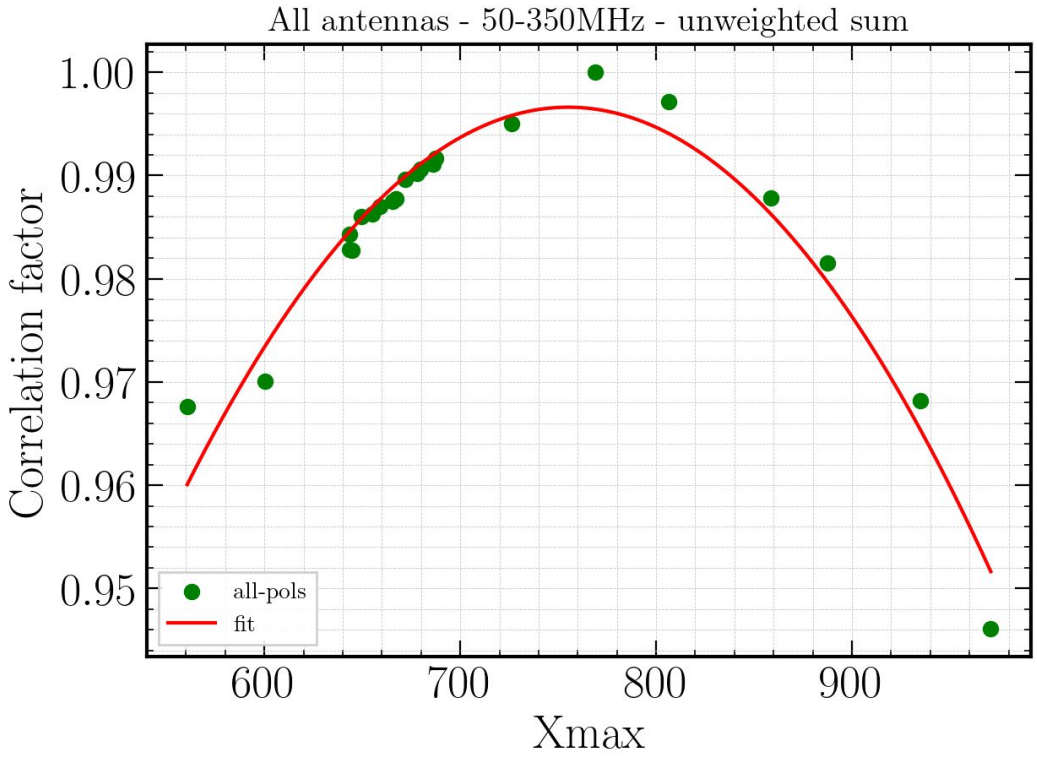
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Using the correlation factor to find and compare pulses

event example

reference Xmax = 768.8947165
vs
Xmax reco = 755.2628961

Obvious issue in this approach is the cc values are too high so I am not very optimistic that this is going to work in real world. Should I benchmark it nevertheless?

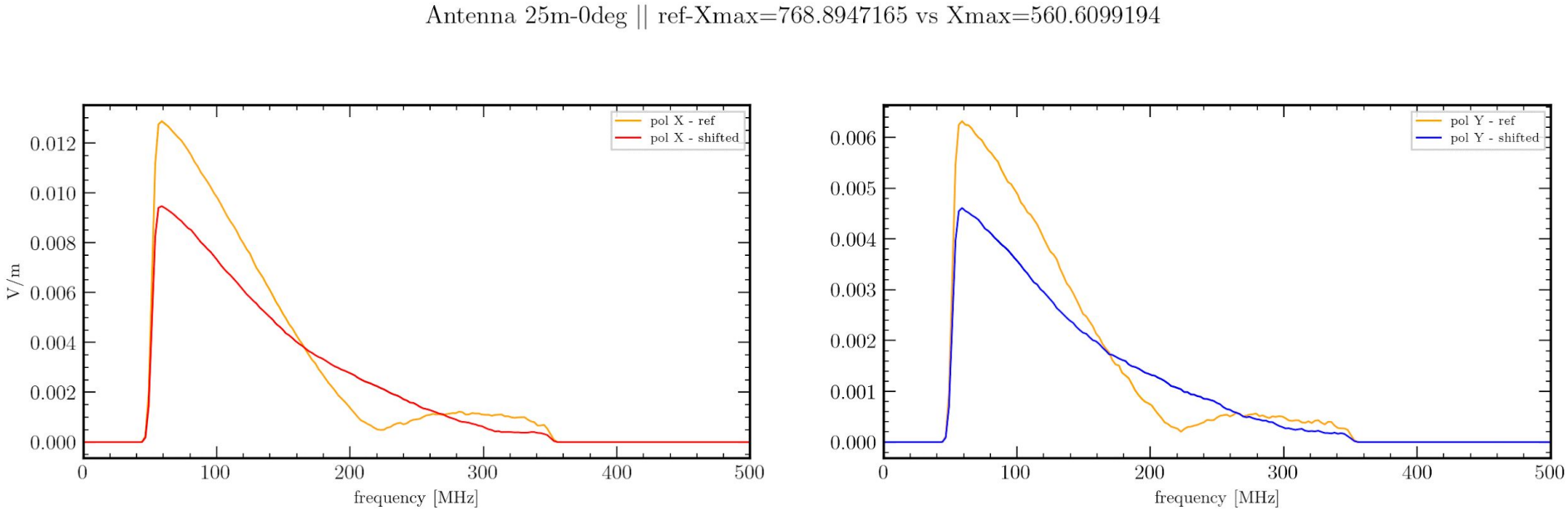


Using the area difference for Xmax reconstruction

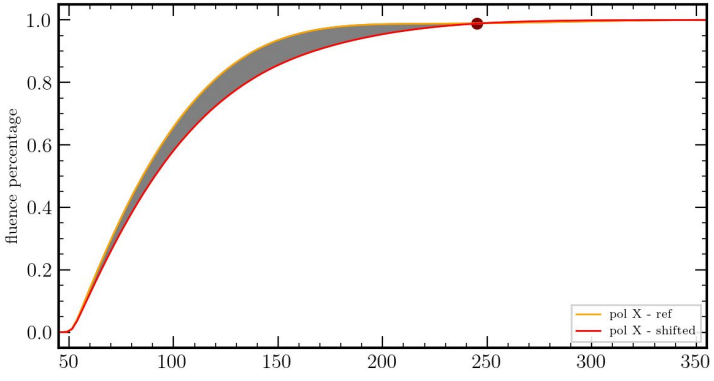
1. Take several starshape simulations which differ only in Xmax and treat one as “data” reference.
2. Study the pulses for every antenna separately.
3. Calculate FFT squared.
4. Calculate the cumulative sum. Last bin of that is the total fluence.
5. Every bin of the cumulative sum I divide by the total fluence (last bin) and I get a fluence percentage for “data” and simulations.
6. Plotting this for “data” and simulations gives us 2 curves where their difference in area I treat as a metric.
7. For example, if the difference in area is zero then I found the “true” Xmax.

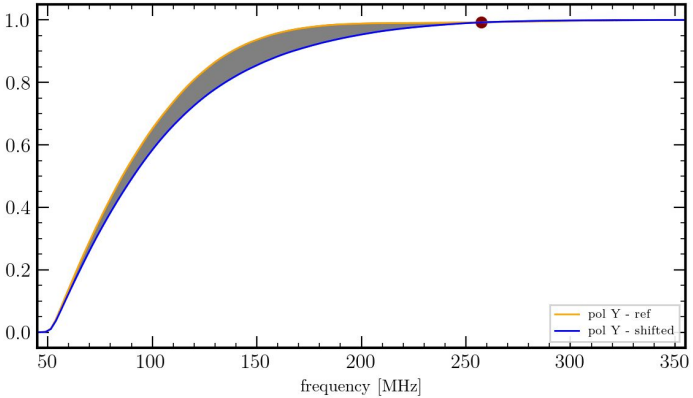


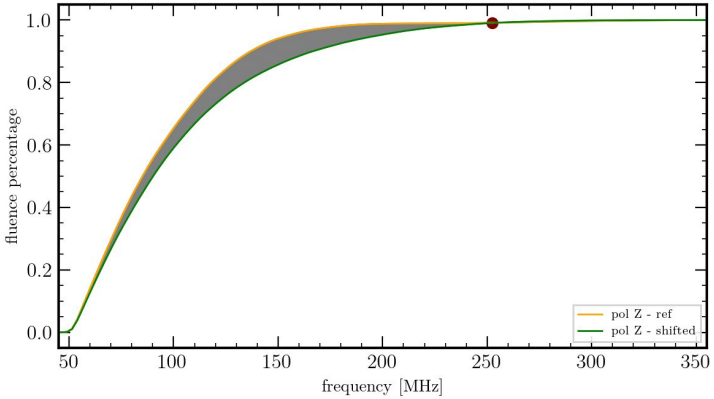
Using the area difference for Xmax reconstruction



Antenna 25m-0deg || ref-Xmax=768.8947165 vs Xmax=560.6099194

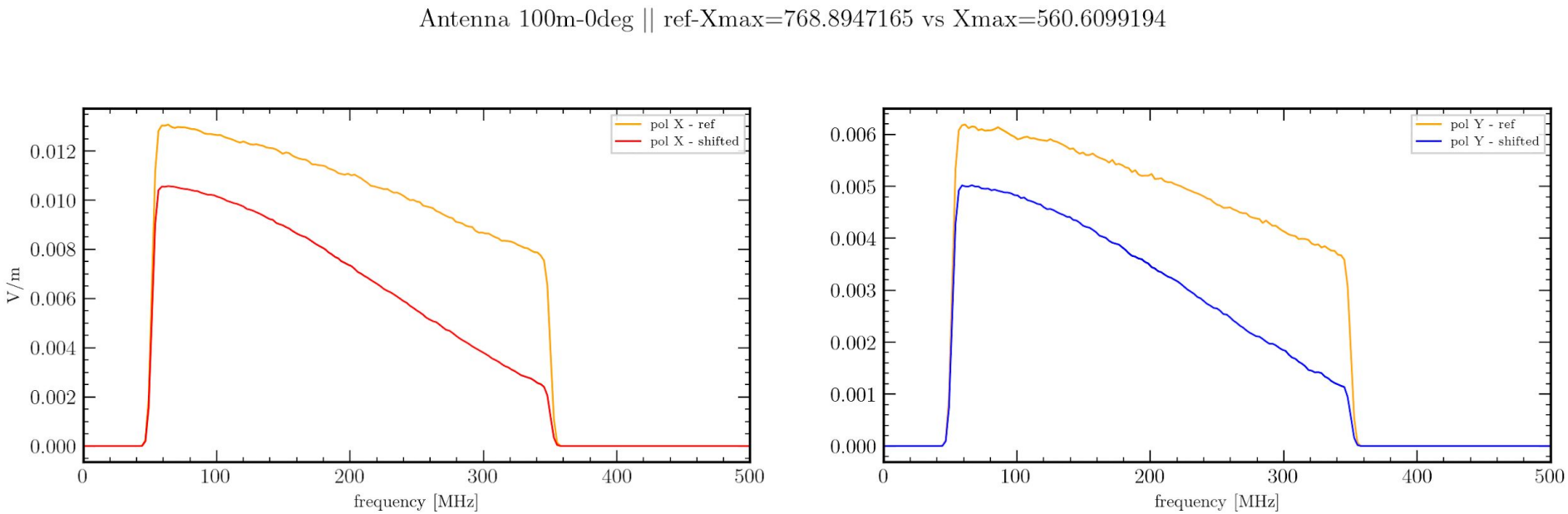




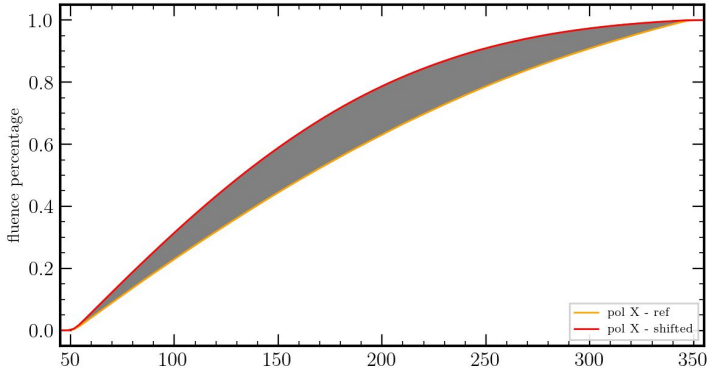


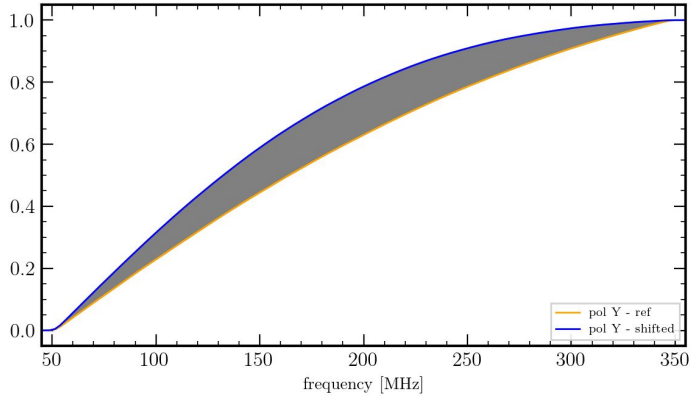
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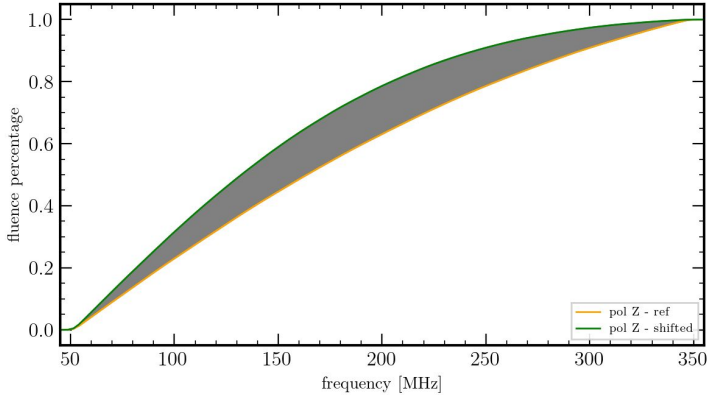
Using the area difference for Xmax reconstruction



Antenna 100m-0deg || ref-Xmax=768.8947165 vs Xmax=560.6099194



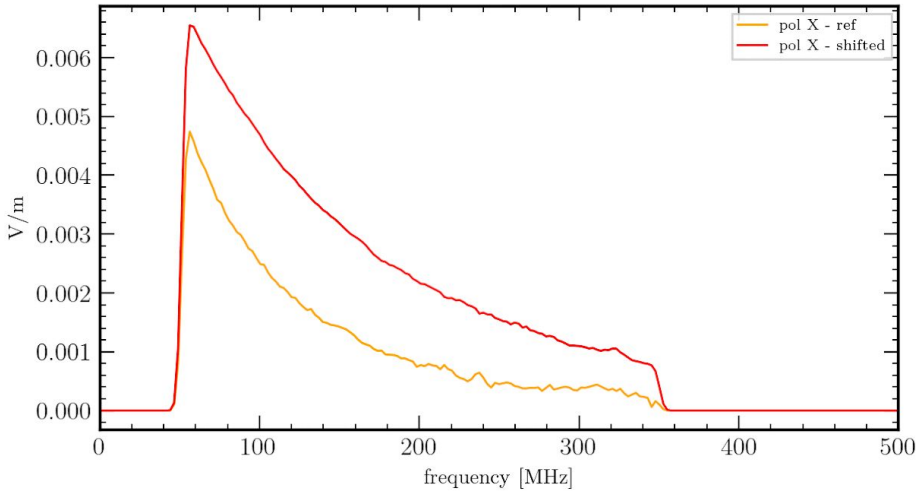


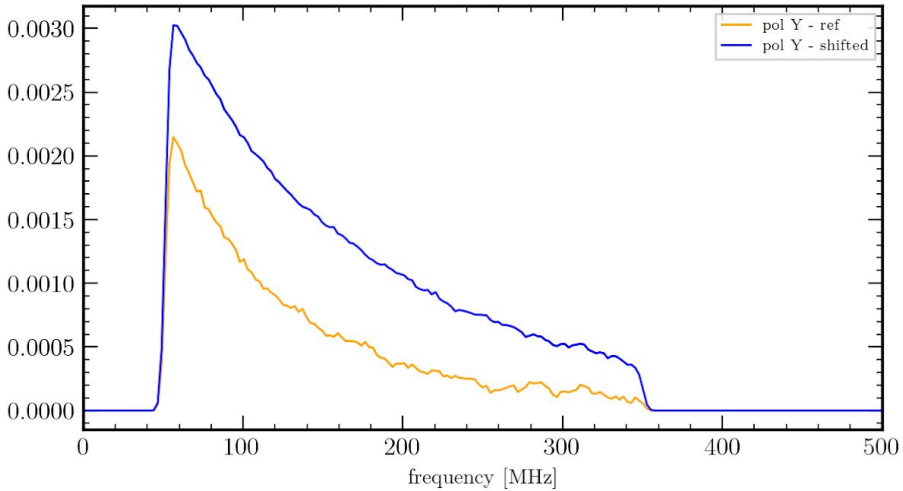


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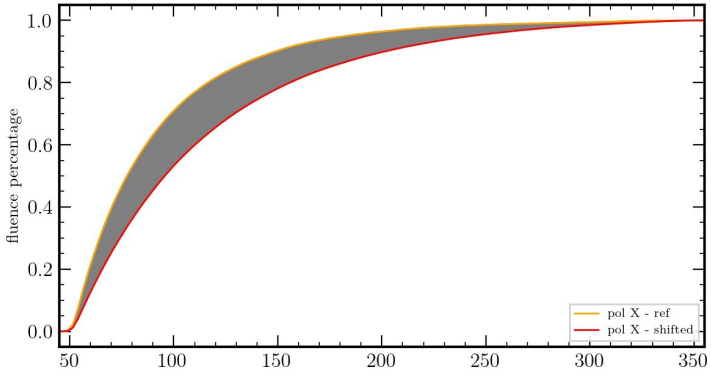
Using the area difference for Xmax reconstruction

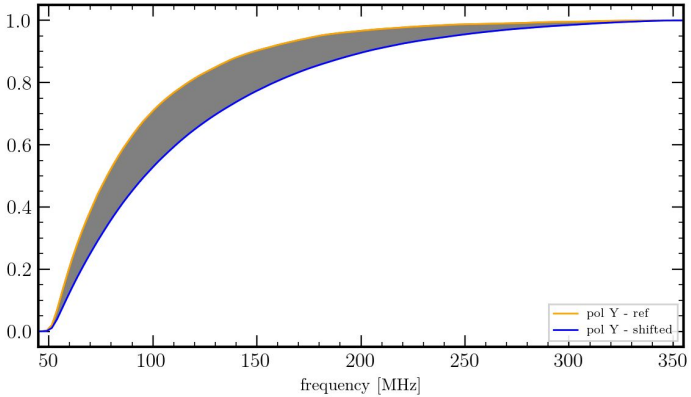
Antenna 250m-0deg || ref-Xmax=768.8947165 vs Xmax=560.6099194

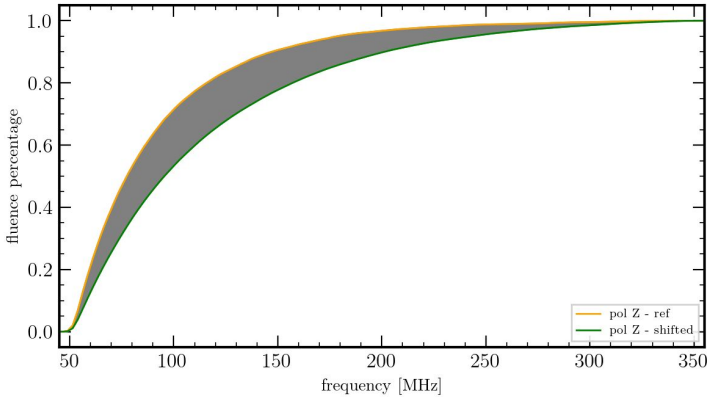




Antenna 250m-0deg || ref-Xmax=768.8947165 vs Xmax=560.6099194







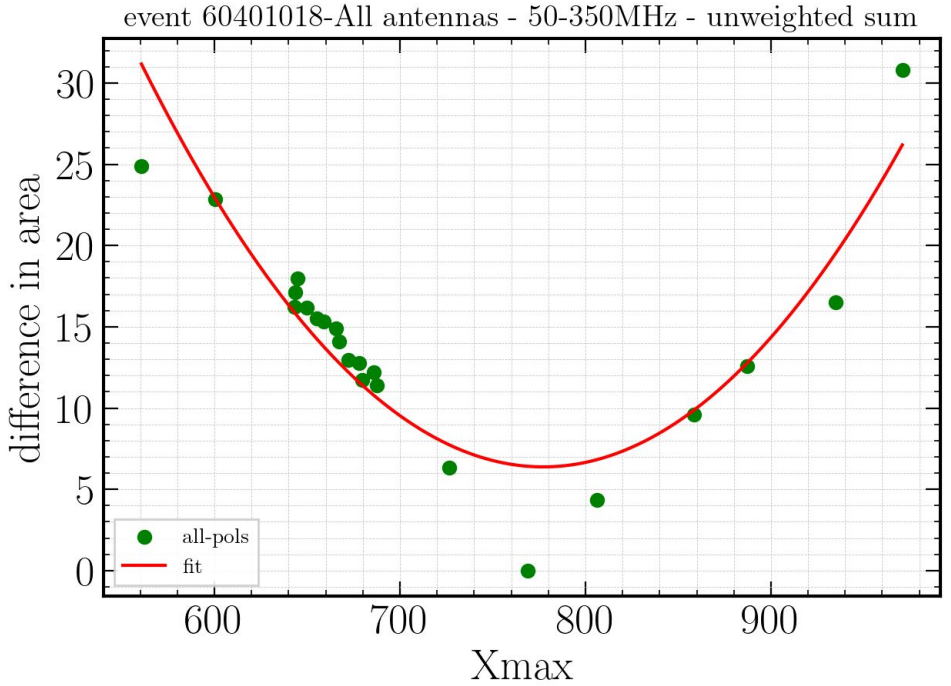
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Using the area difference for Xmax reconstruction

event example

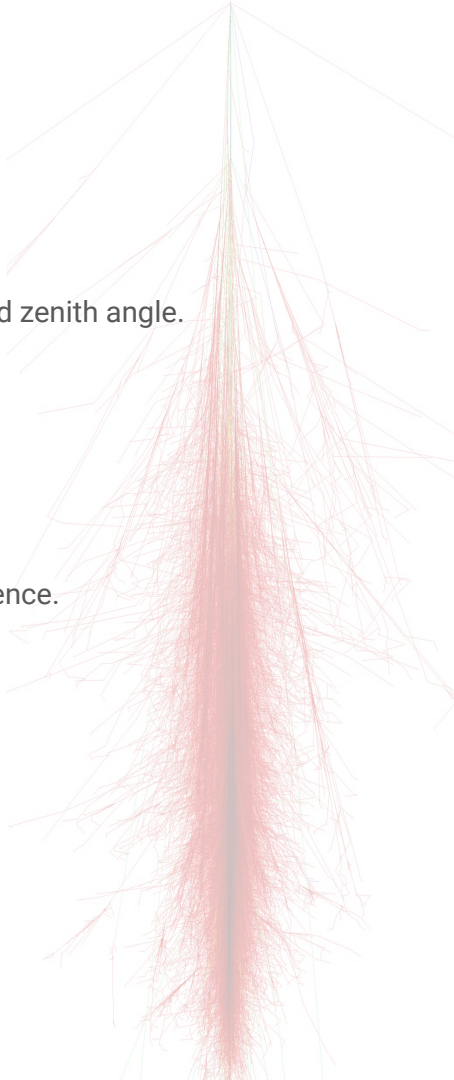
reference Xmax = 768.8947165
vs
Xmax reco = 777.0278914

This seems way more promising
so I benchmarked it

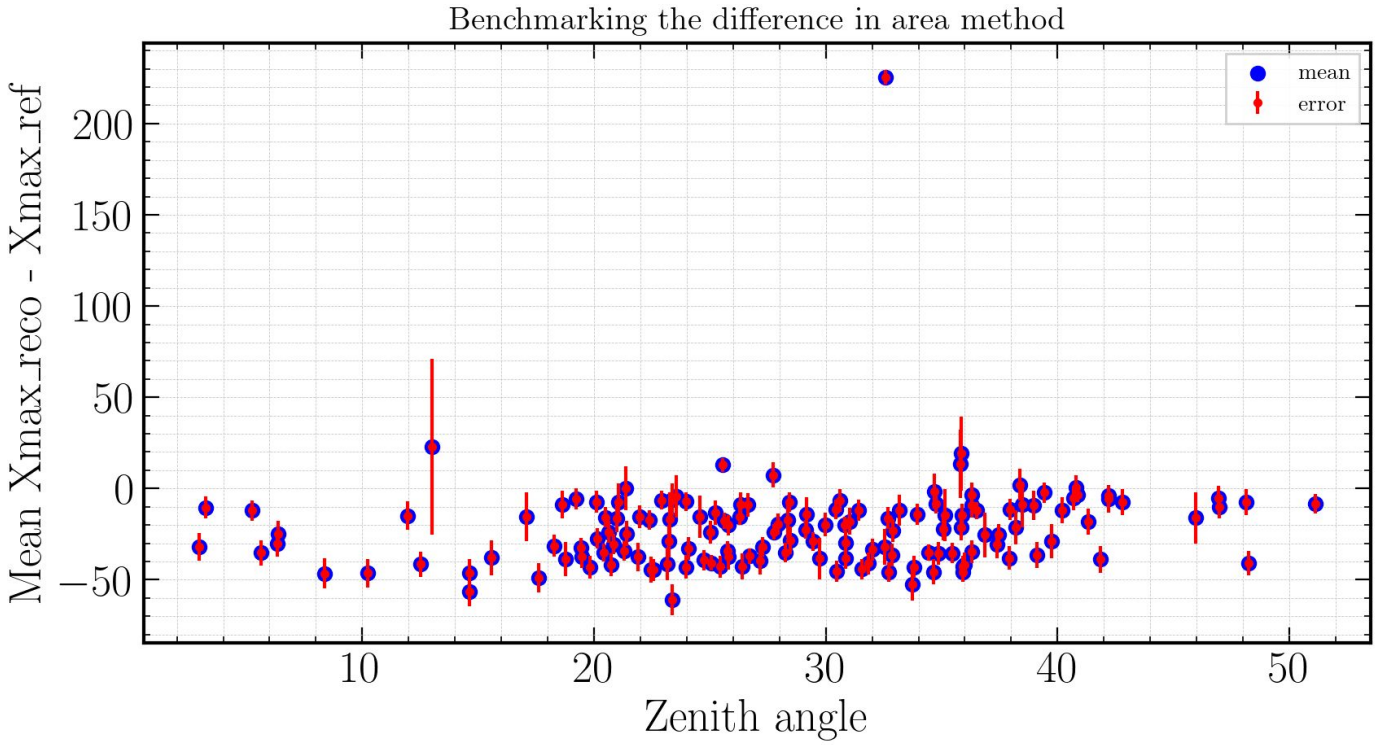


Using the area difference for Xmax reconstruction

1. Picked 148 events from coma whose energy is > 10^17.3 eV. So the simulations differ in energy and zenith angle.
2. Mixed iron and proton showers from the last folder of iterations.
3. Every event has ~30 simulations. Some have more, even 142!
4. The simulations differ only in Xmax.
5. I sorted the Xmax values and left out the smallest and the biggest value from them being the reference.
6. I compared each one of those with the rest of the simulations for every event.
7. Every data point you see in the benchmark plot is the mean value for each simulation.



Using the area difference for Xmax reconstruction

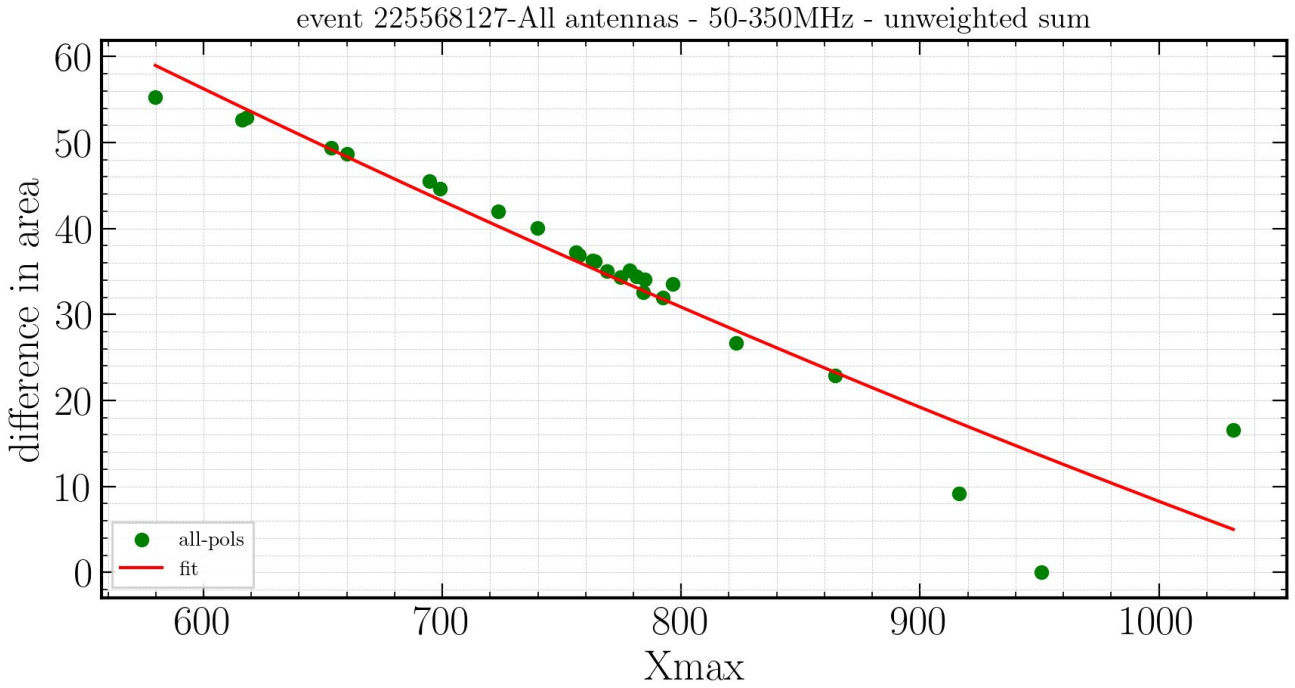


Using the area difference for Xmax reconstruction

event example

reference Xmax = 950.6784308
vs
Xmax reco = 1031.184527

Edge case!

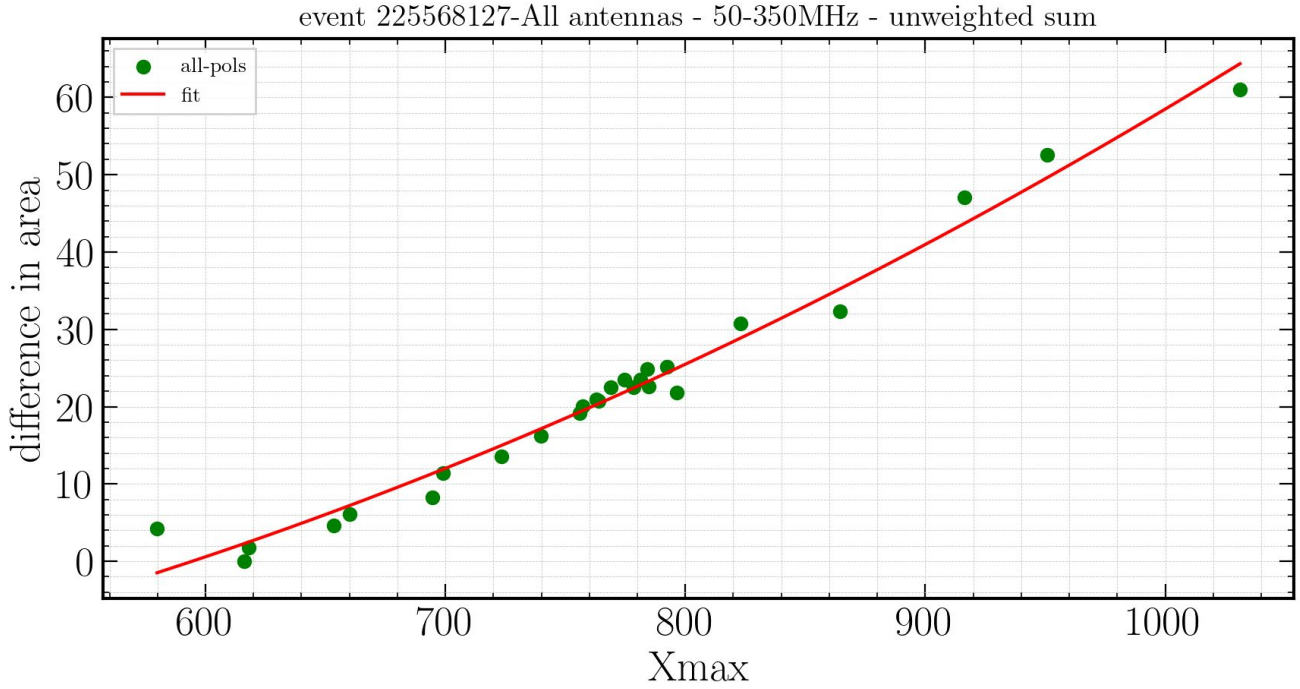


Using the area difference for Xmax reconstruction

event example

reference Xmax = 616.0425745
vs
Xmax reco = 579.8163005

Edge case!

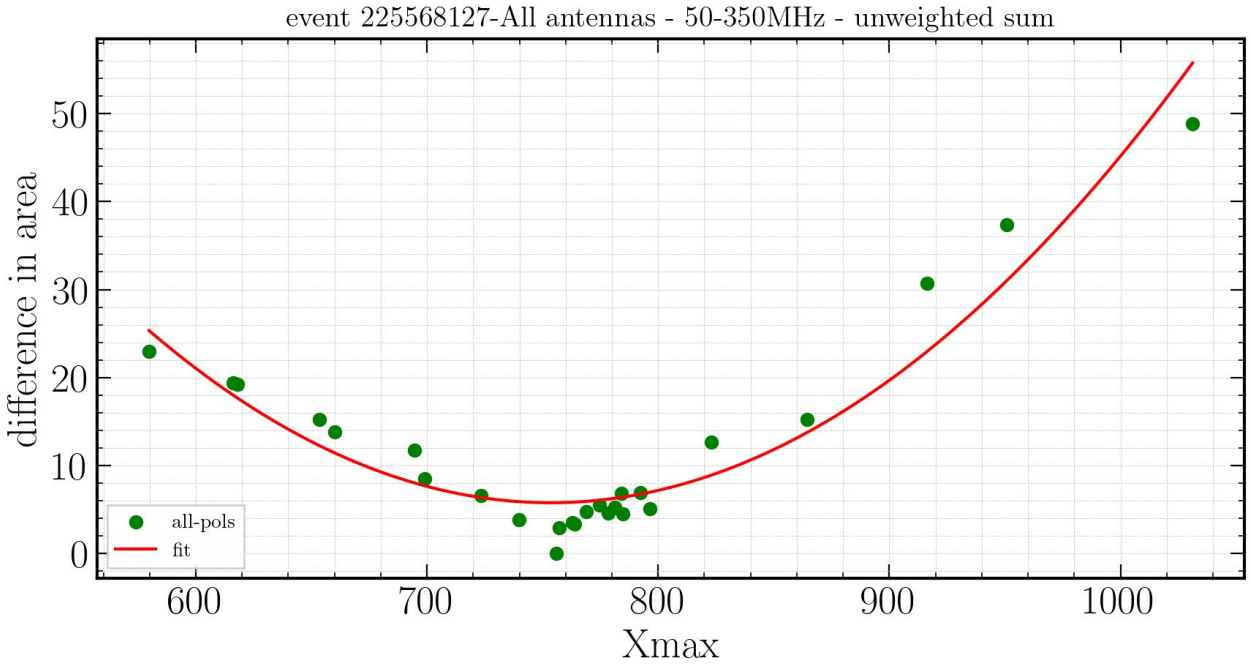


Using the area difference for Xmax reconstruction

event example

reference Xmax = 755.9752828
vs
Xmax reco = 753.3151983

Very good case! Many data points around.

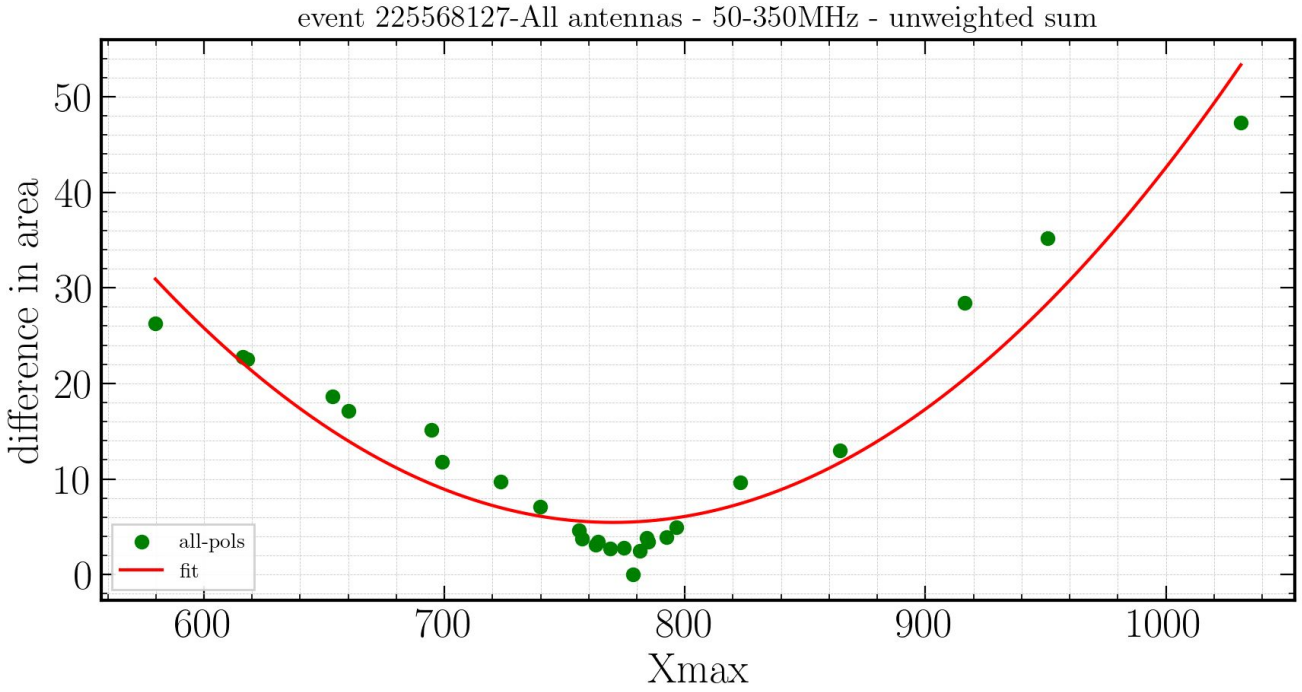


Using the area difference for Xmax reconstruction

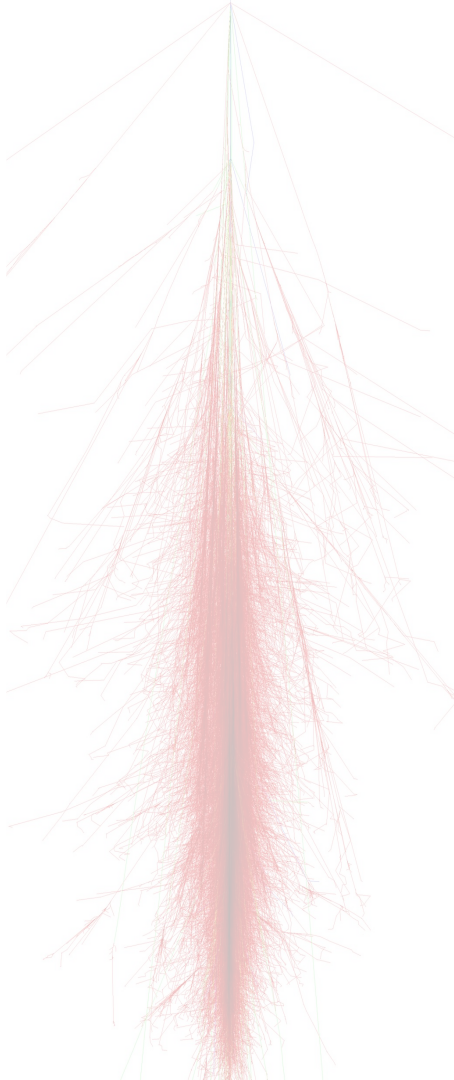
event example

reference Xmax = 778.3648809
vs
Xmax reco = 770.0325400

Good case, because there are enough data points nearby



Thank you!



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