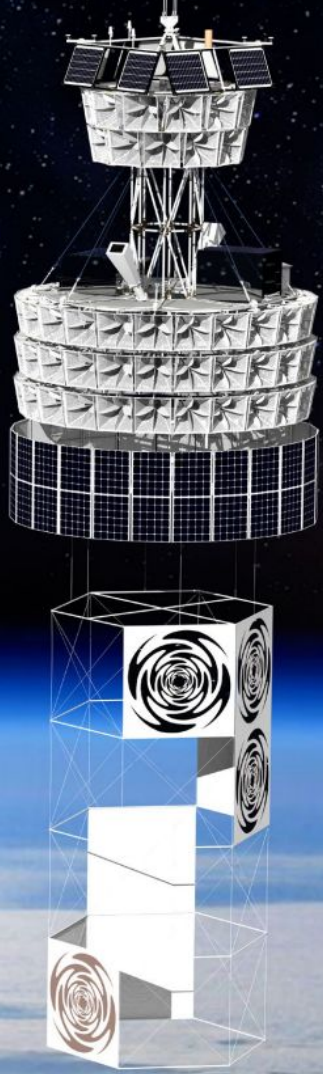
The Low Frequency Instrument of PUEO

Yuchieh Ku

For the PUEO Collaboration

ARENA June 12th

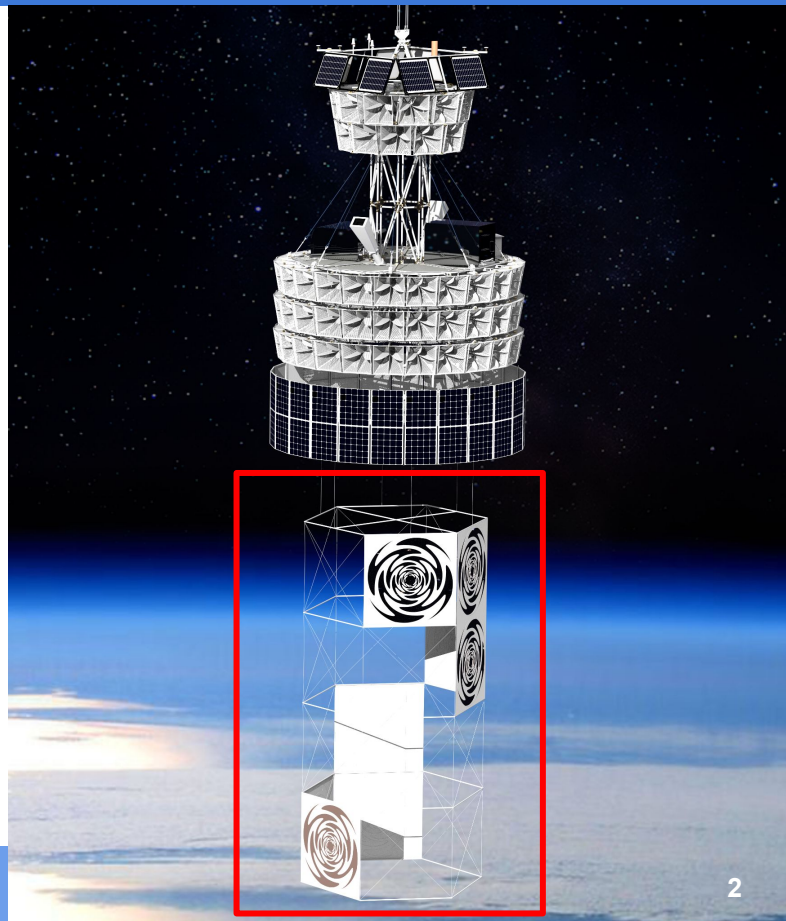


PUEO

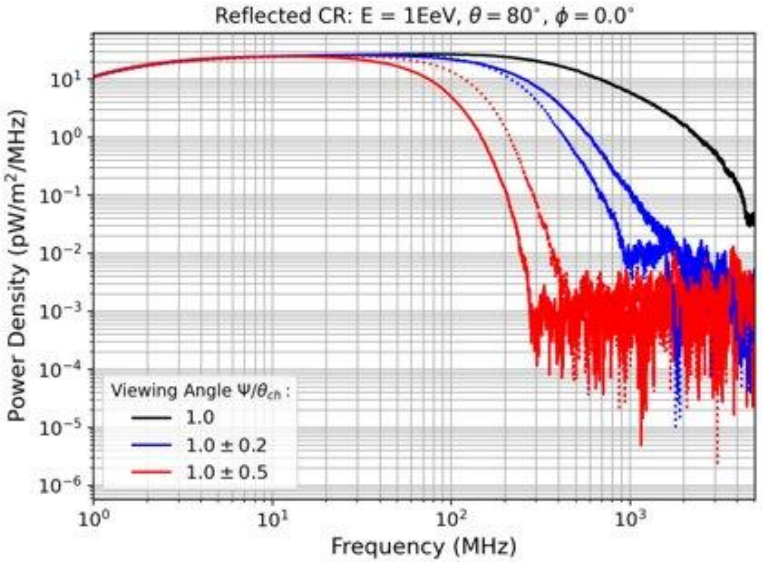
PennState
University Park

Low Frequency Instrument (LF)

- Deployable that is composed of eight low frequency antennas in an hexagon array.
- Operate at 50-500 MHz, compared to 300-1300 MHz of the horn antennas of the main instrument (MI).



Why LF?



A. Cummings

- Power spectra of the extensive air shower are low-frequency dominant.
- LF provides independent measurements of event's polarization, polarity, reconstructed direction etc. The overlapping frequency band between MI and the LF allows cross-validation of the signals.

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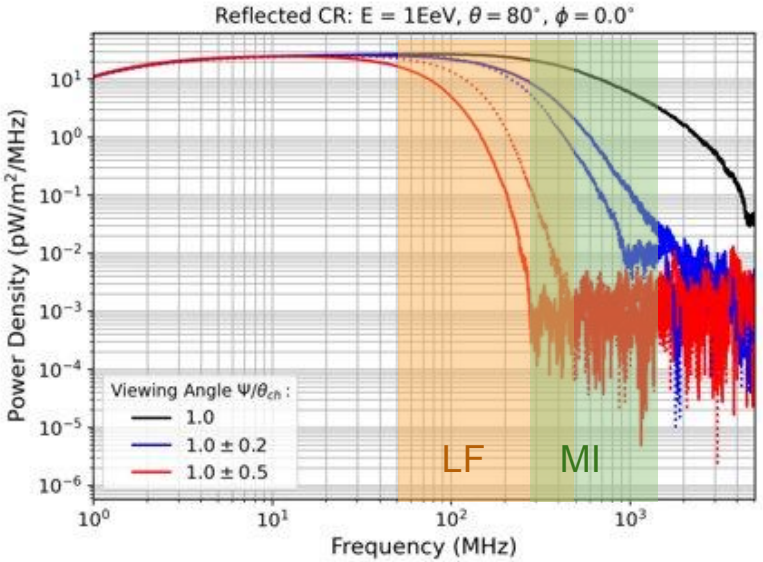

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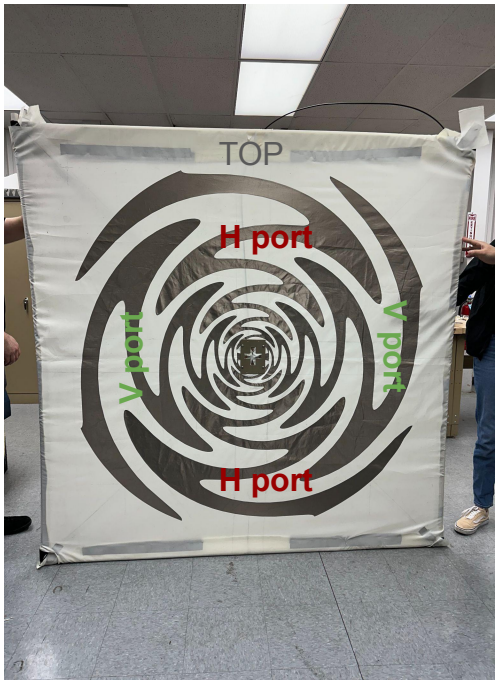
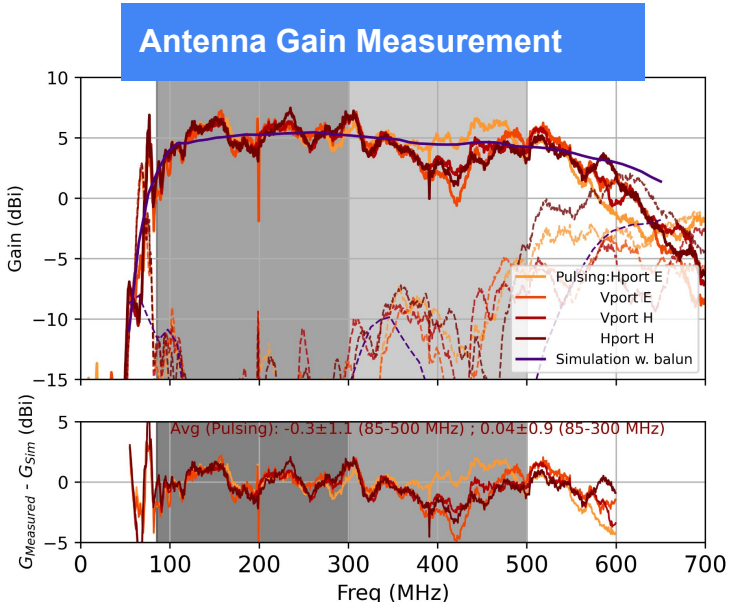
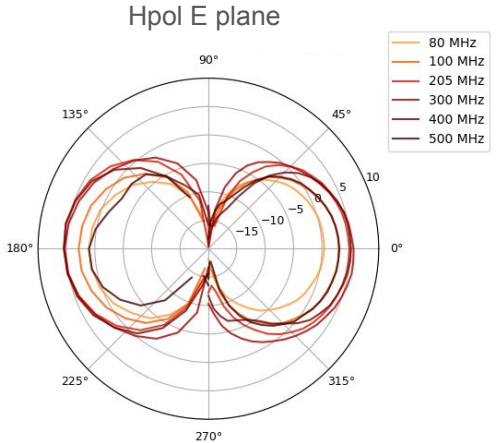
LF Antenna Design and Measurements I

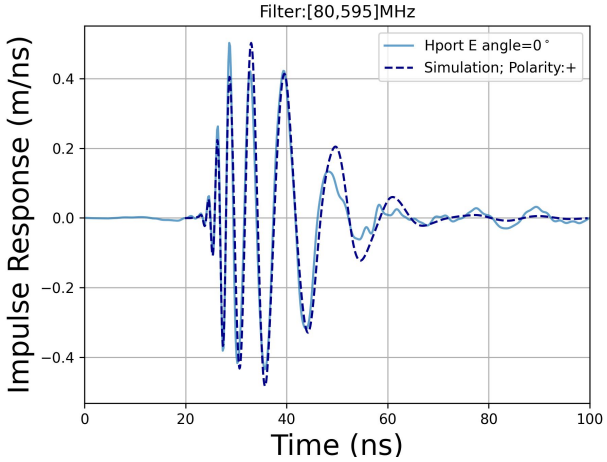


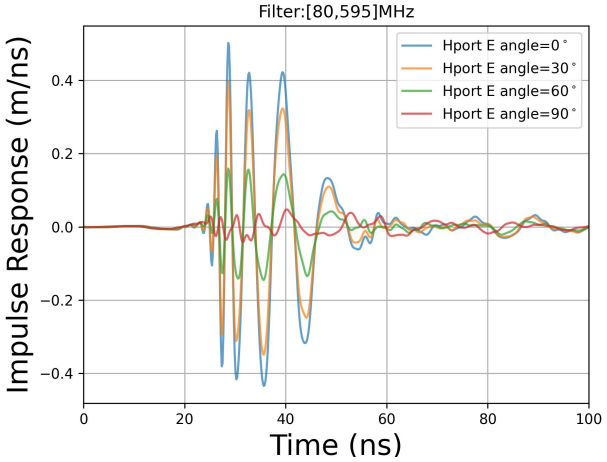
- Log-periodic "Sinuous" antenna operate at 50-500 MHz.
- Dual polarized, independent Horizontal/Vertical polarization.
- 4-6 dBi gain at boresight.
- ± 30° antenna beam width. Identical back and front lobes.

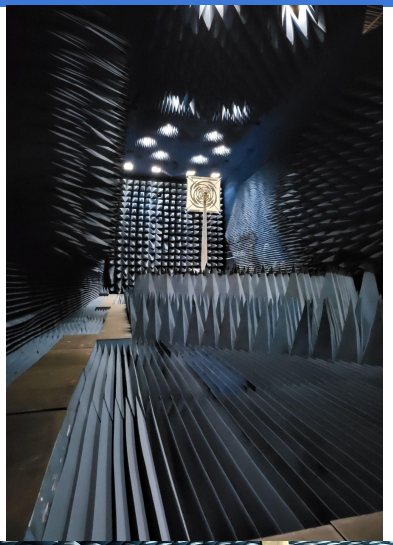


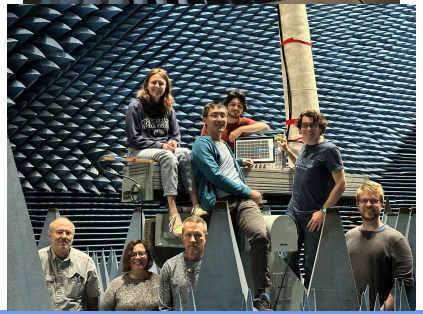


LF Antenna Design and Measurements II



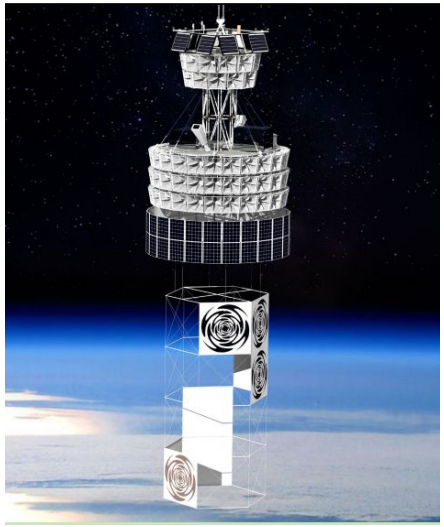


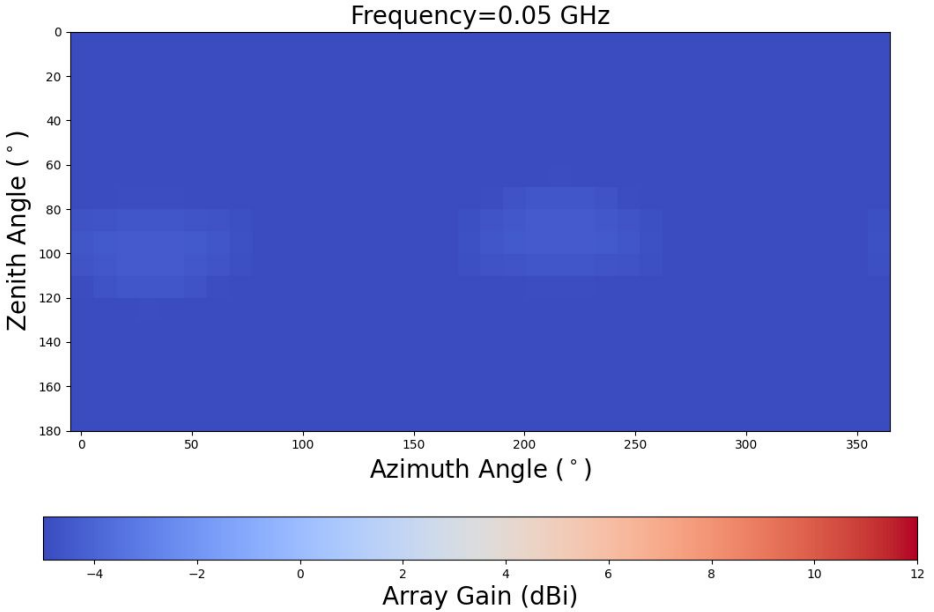




- Impulse response measurements match well with simulations.
- Angular responses have consistent phase response, making the coherent sum over antenna pointing at different directions feasible.

From 1 to 8: LF array Layout





- Hexagon array provides vertical and horizontal baselines for interferometry.
- Keep antennas from blocking each other.

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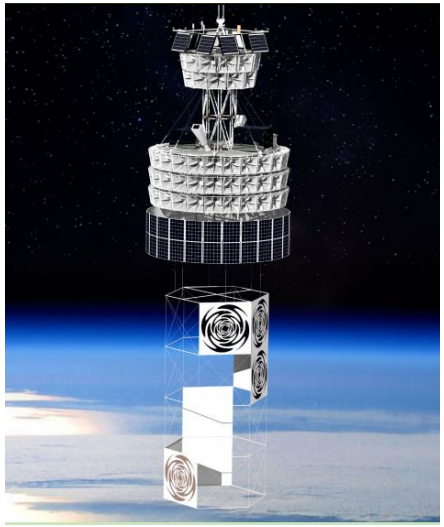

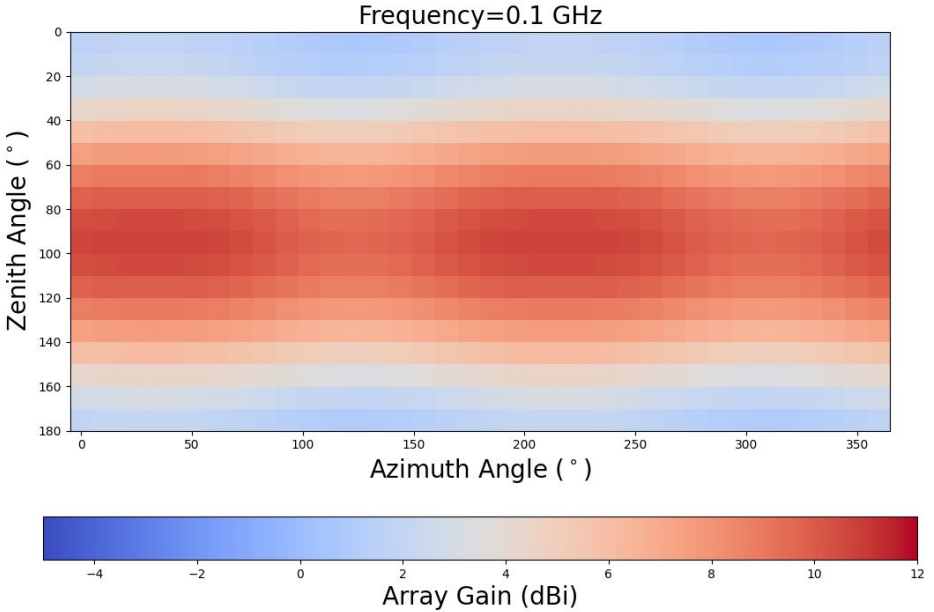

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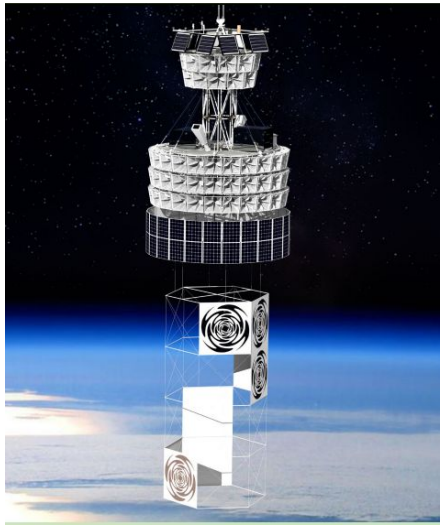

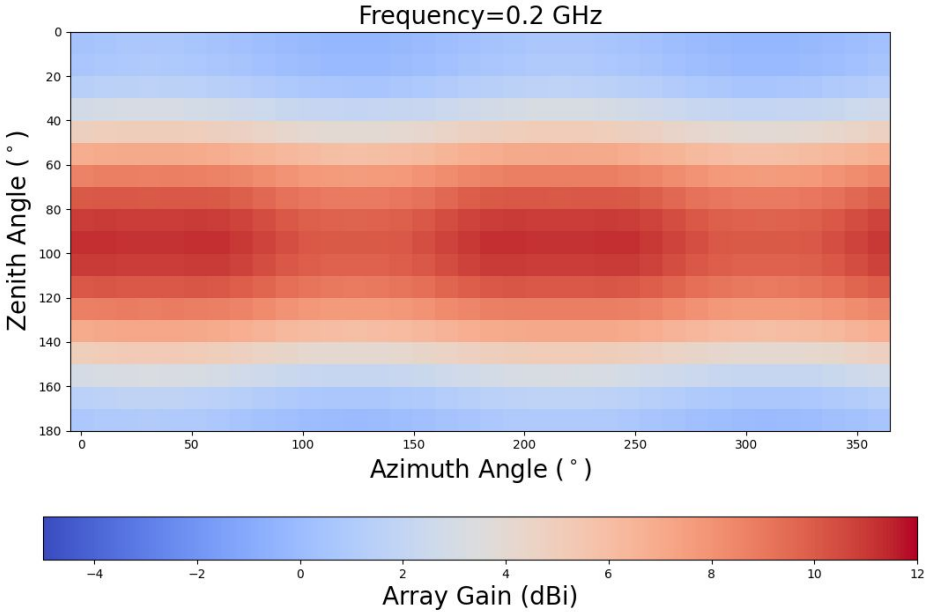

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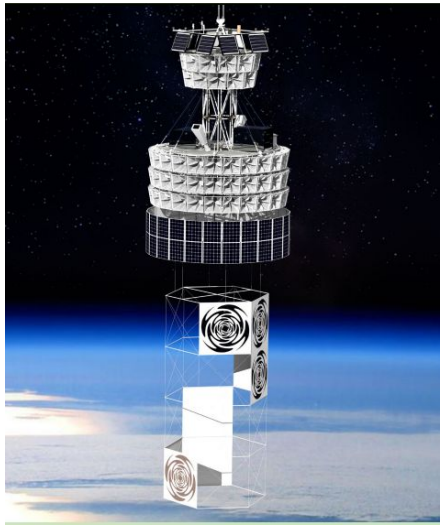

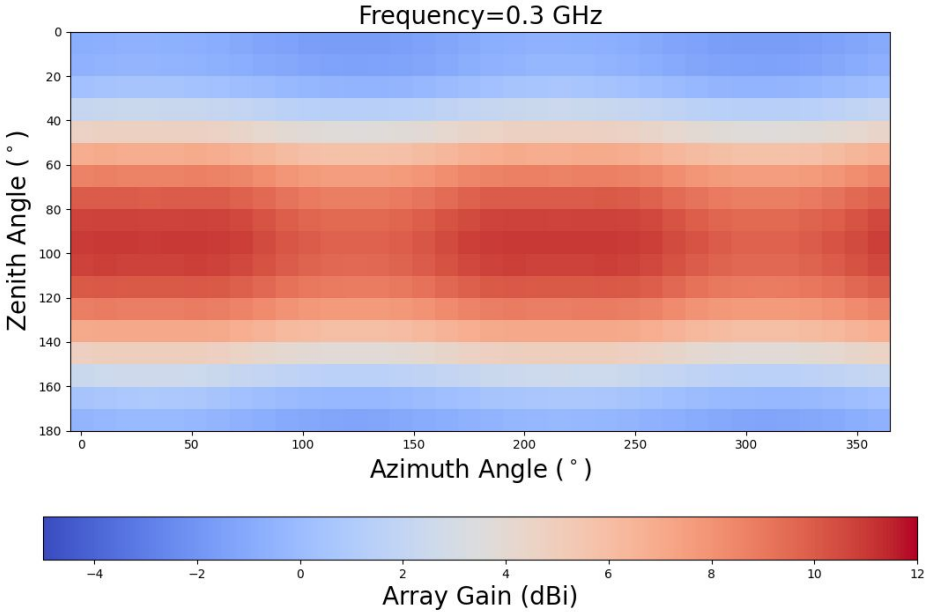

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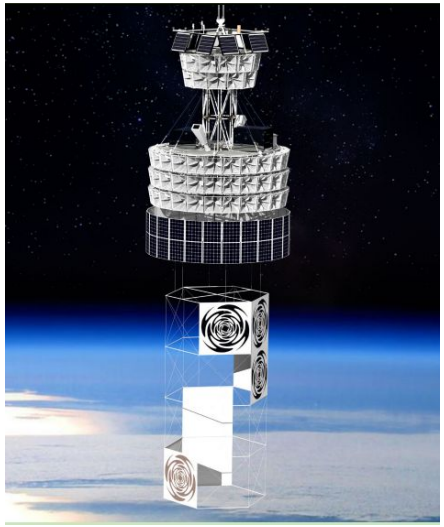

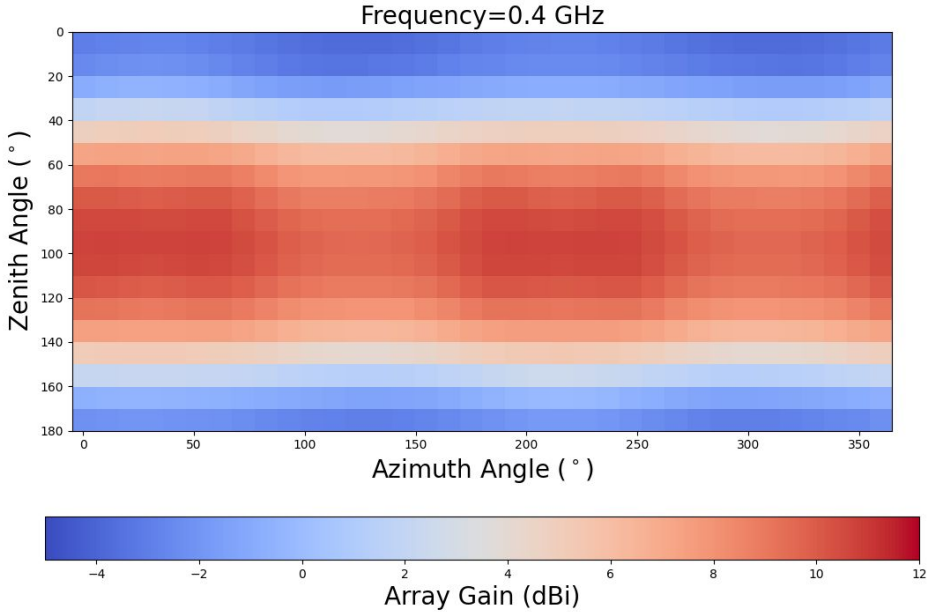

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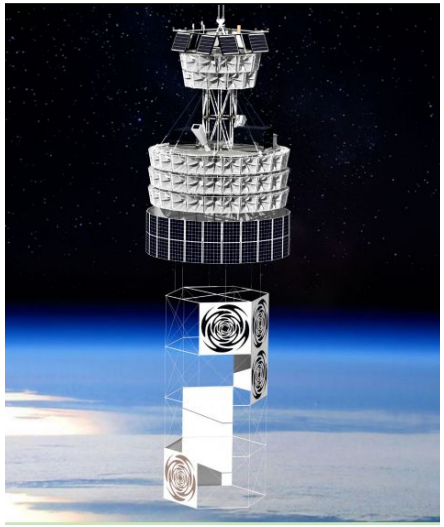

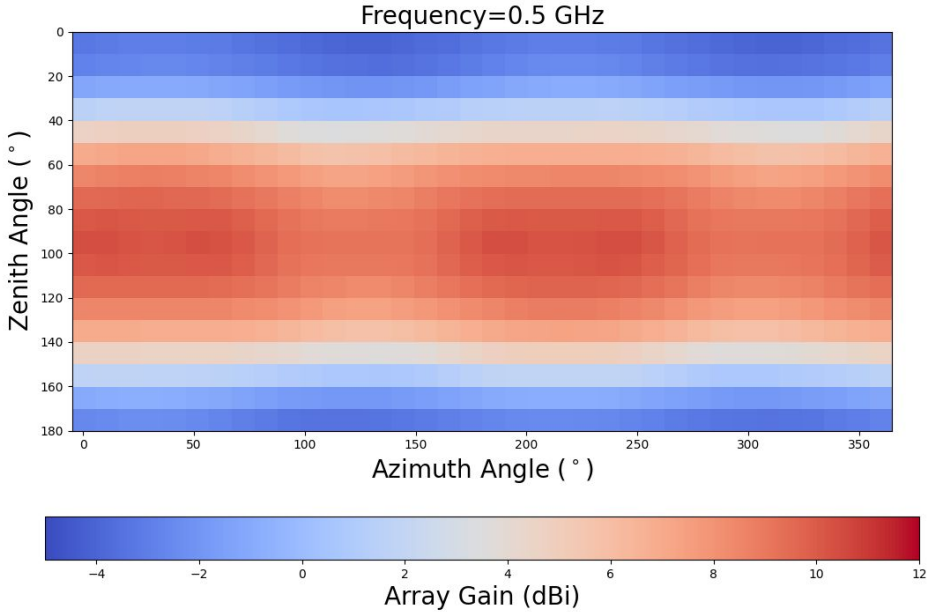

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How to deploy the LF ?

- Before deployment, LF is folded compactly in the deck of payload.
- Gravity deployment, like a “Chinese lantern”.
- Deployment tests successfully demonstrated 4-layer deployment with cables, mock antennas, and electronic boxes.

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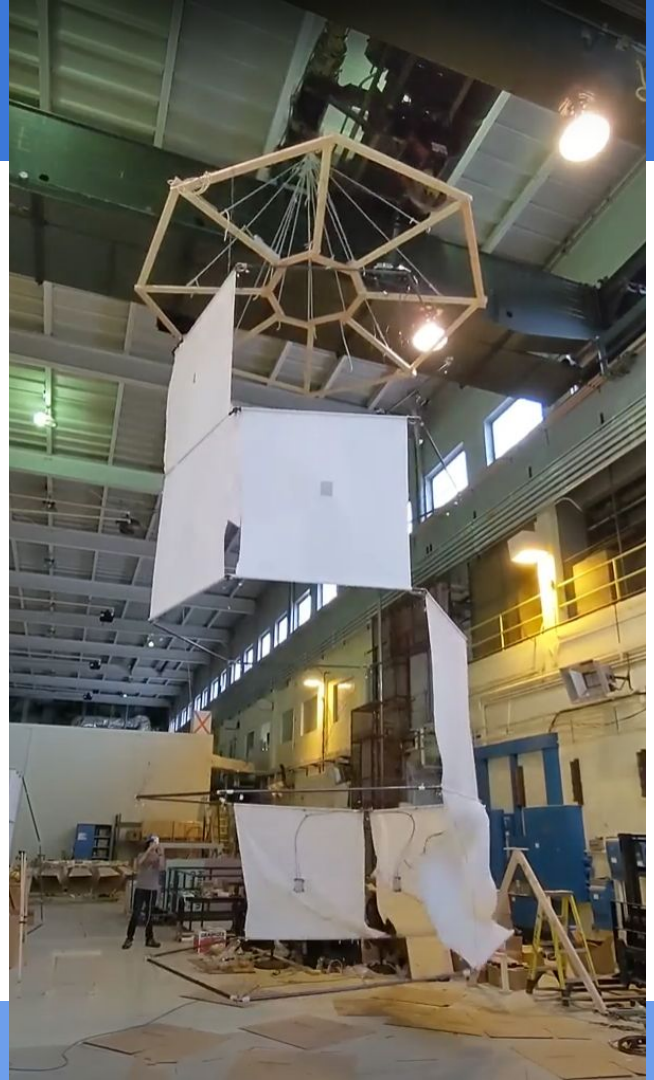

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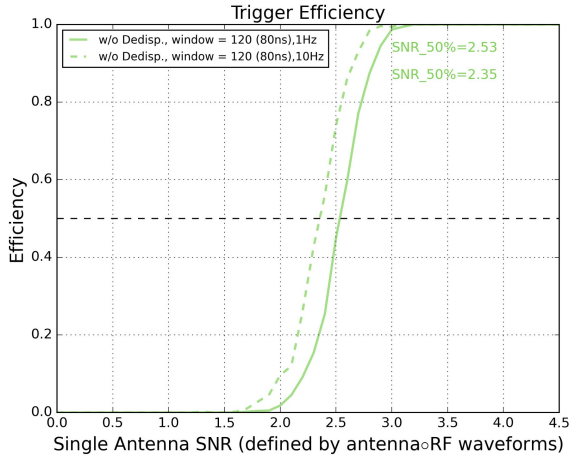
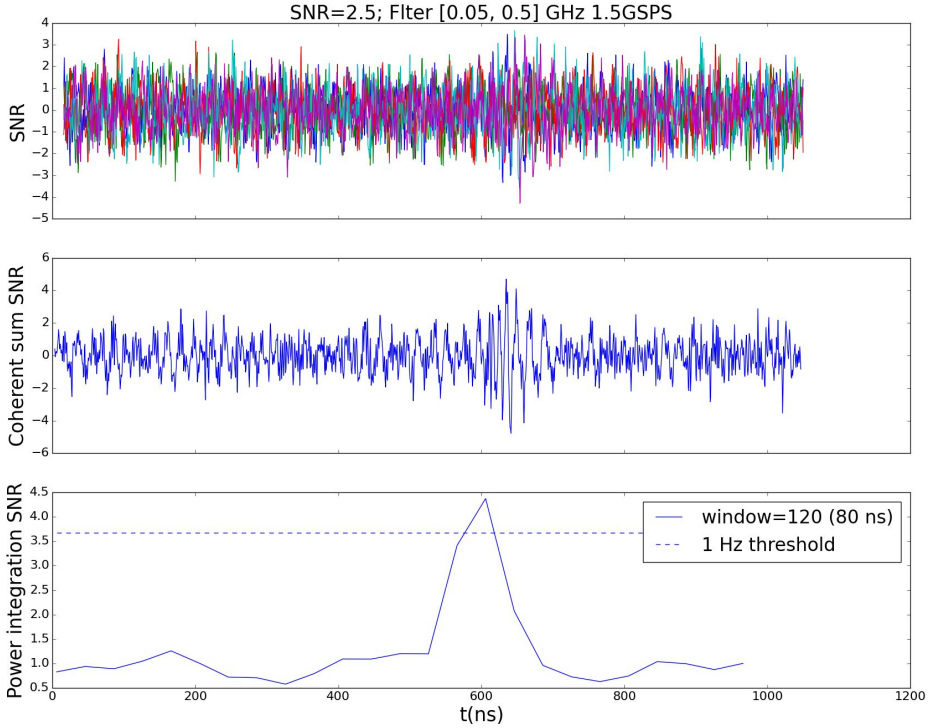
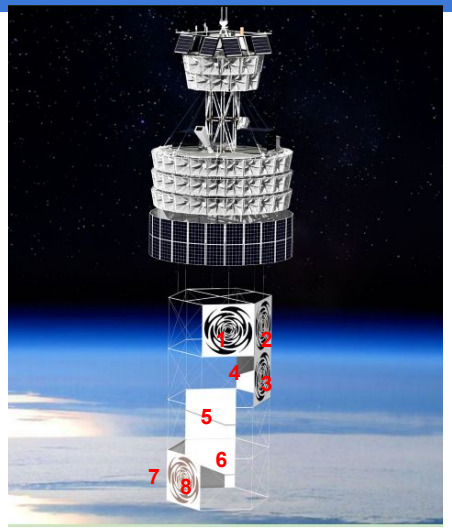
LF Trigger

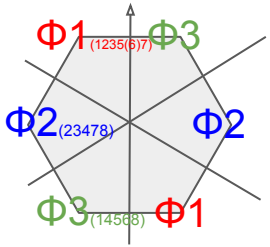
- Interferometric trigger on 5 of the 8 antennas.
- Cooperate with the MI trigger with a mutual “OR”.
- Targeting on 1 Hz event rate. (100 Hz for MI)

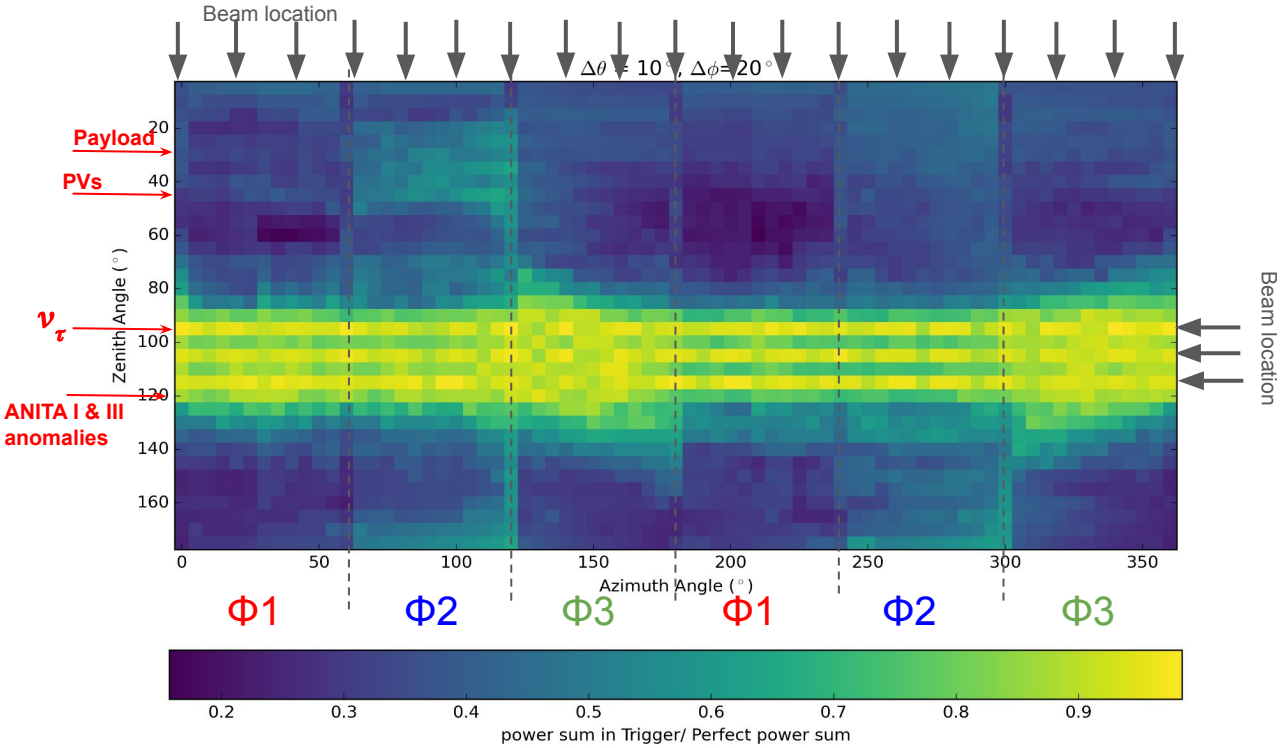




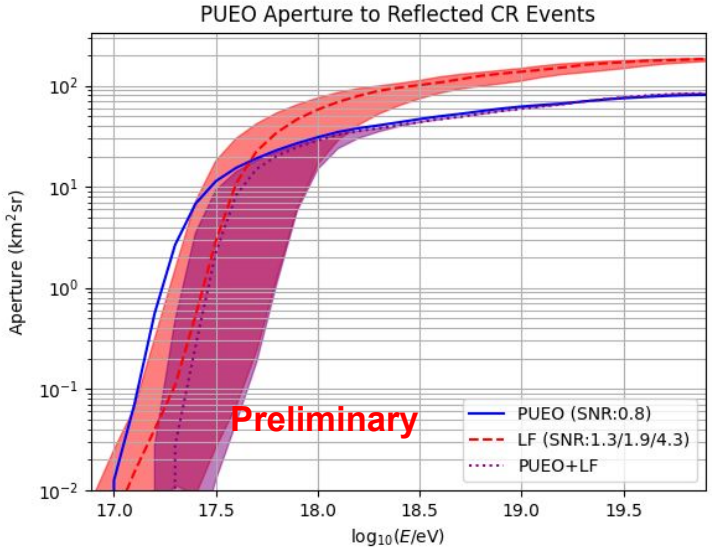
LF Trigger - Full beams power map (54 beams)

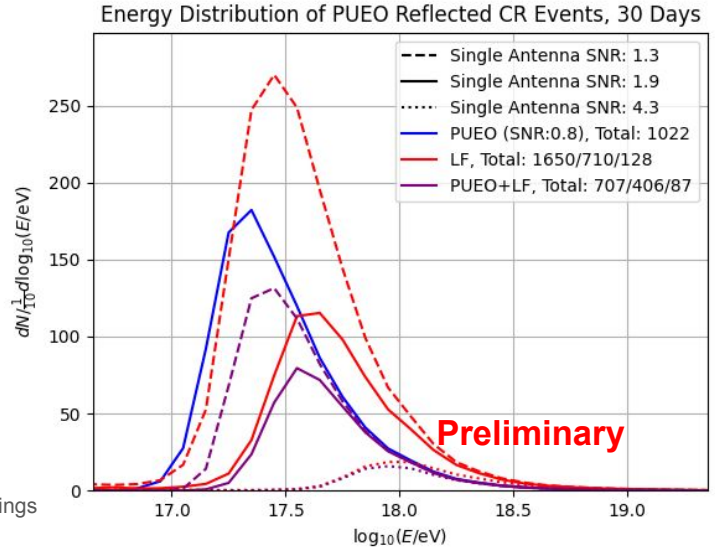






Science of LF: reflected-CRs



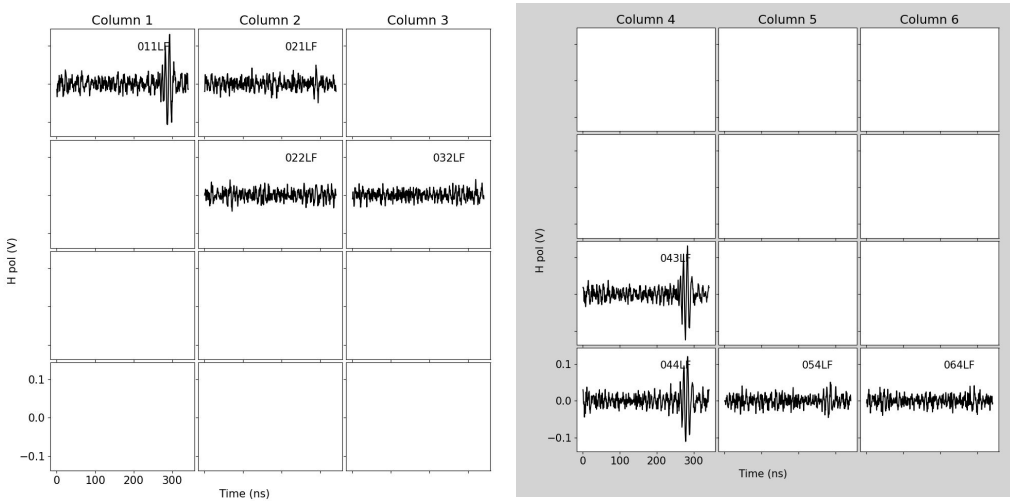


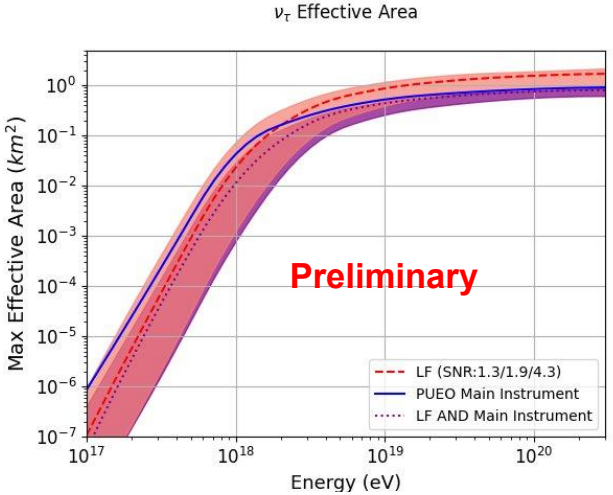
A. Cummings

- LF increases PUEO's aperture to the CRs.
- A thousand reflected CR events are expected in PUEO's flight. With information from both MI and the LF.

Science of LF: Earth-skimming Tau events

- A simulated 100 EeV ν_τ event, with ~1 EeV shower energy.
- For energy above EeV, LF has a larger effective area compared to the MI.



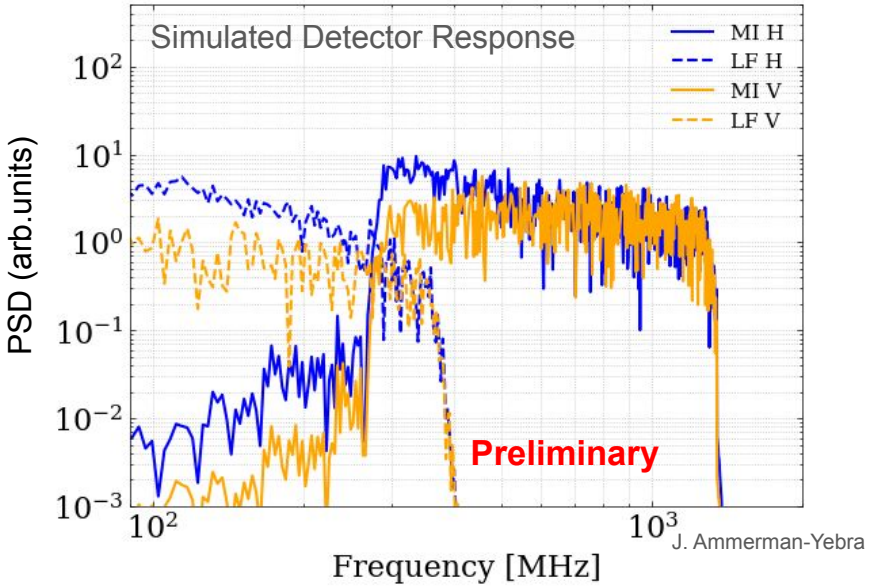


Conclusions

- 8 sinuous antennas will be dropped down from the payload to make the LF.
- LF will independently quantify signal properties, aiding PUEO in categorizing backgrounds for neutrino searches.
- The LF employs the interferometric trigger, and will corporate with the MI trigger.
- In PUEO's air shower channel, LF provides larger effective area to the CRs and the tau neutrinos compared to the MI for energy above EeV.
- Significant progress is being made in instrument construction. Stay tuned for the flight in 2025!

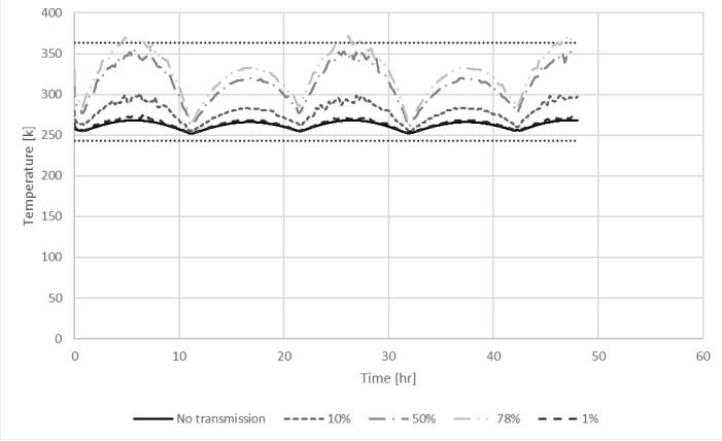
Back up

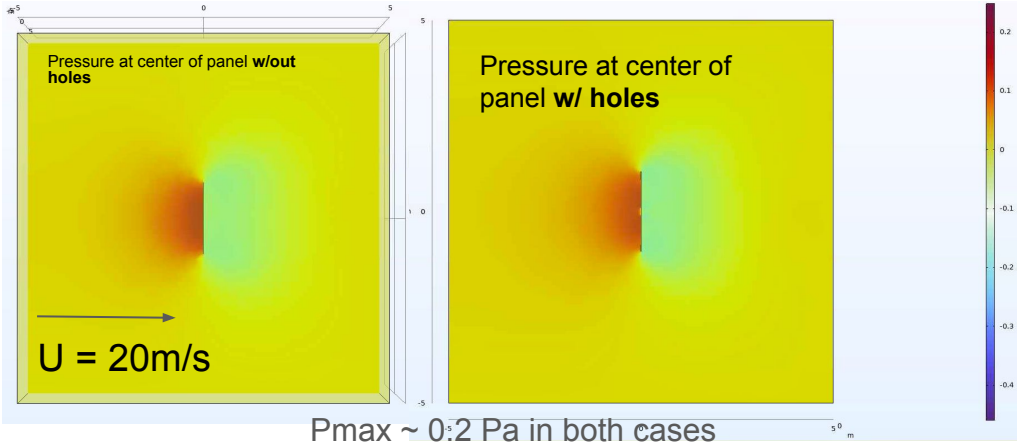
Simulated detector response to an air shower



Antenna Wind Loading / Thermal

- Thermal study suggests that a >0.1 mm polyester heat shield is necessary.
- Wind study suggests that we don't need additional holes cut on the panel for wind to pass through.





Pmax ~ 0.2 Pa in both cases