

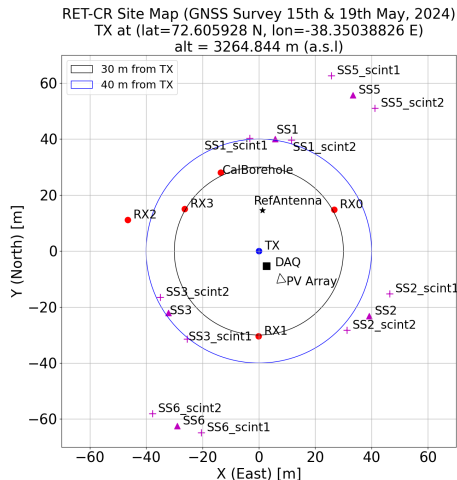
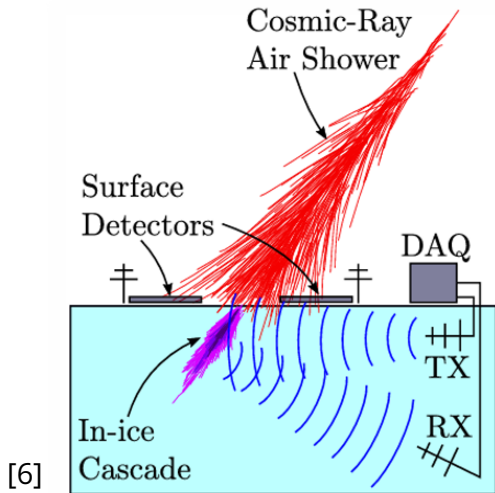
Toward A Sub-Threshold Search For Cosmic Rays In The Radar Echo Telescope

Curtis McLennan on behalf of the RET Collaboration

University of Kansas: Department of Physics and Astronomy

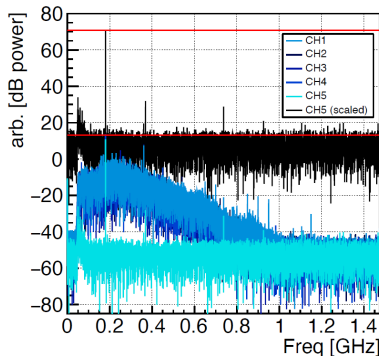


Radar Echo Telescope for Cosmic Rays

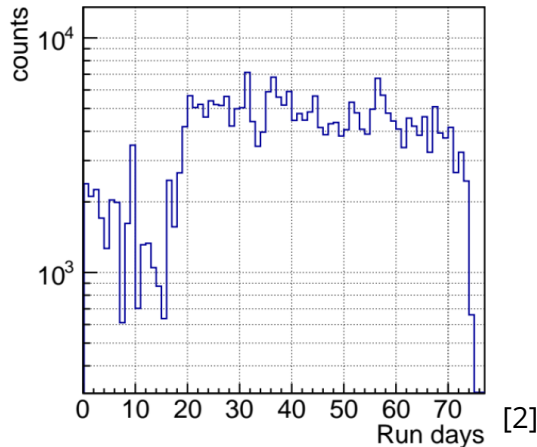


2024 Deployment

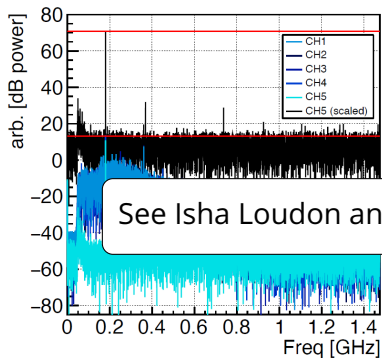
[2]



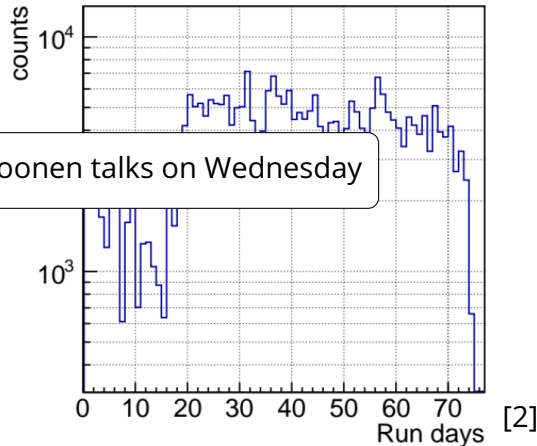
- ~ 4000 cosmic ray triggers a day
- Overall nominal technical and scientific performance



2024 Deployment



See Isha Loudon and Jannes Loonen talks on Wednesday

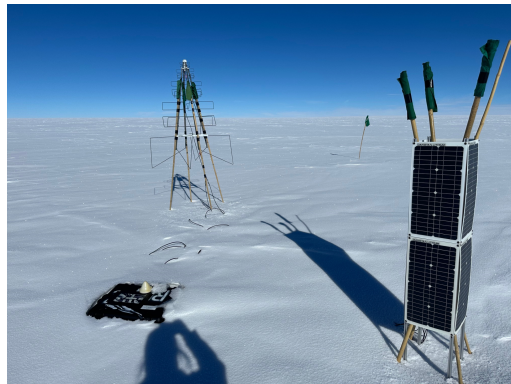


[2]

- ~ 4000 cosmic ray triggers a day
- Overall nominal technical and scientific performance

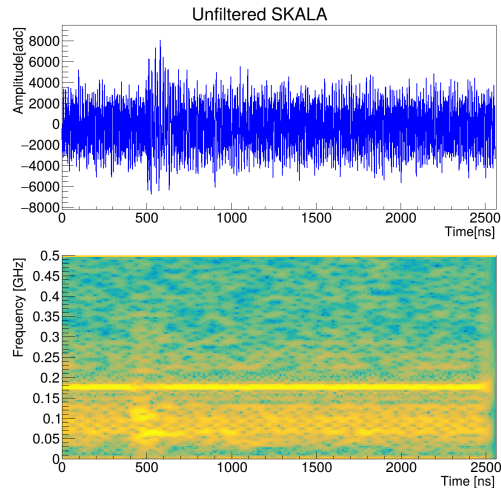
Sub-Threshold Analysis

- Search for low SNR radar signals
- Applications for future RET-N trigger
- Use RFI contaminated surface antennas to develop sub-threshold techniques
- Focusing on weak signal extraction with Matched Filter Singular Value Decomposition (MF-SVD)

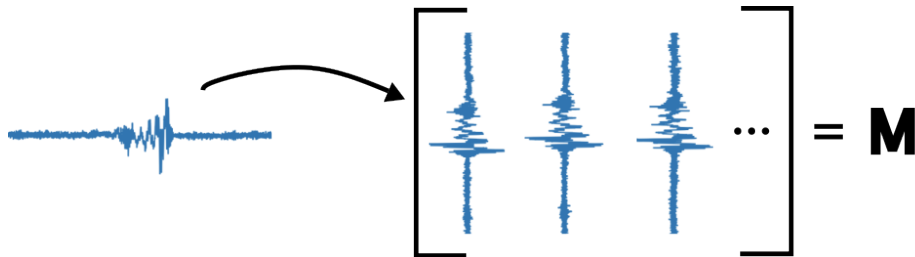


Sub-Threshold Analysis

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Singular Value Decomposition



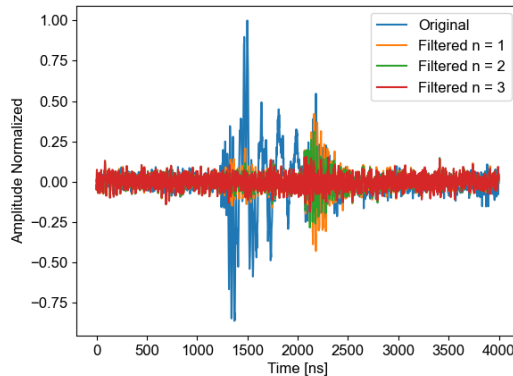
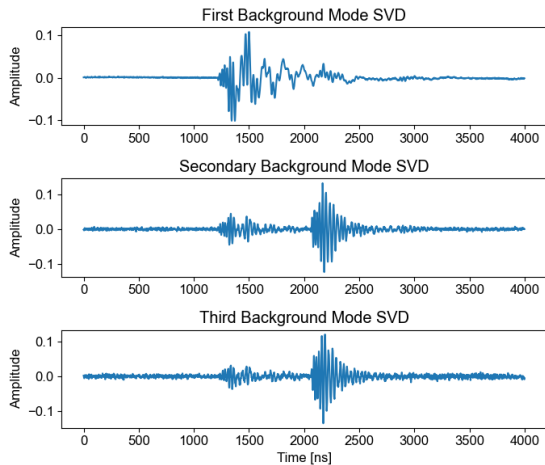
Building the decomposition matrix from representative sample of null events with RFI

$$\mathbf{M} = \mathbf{u} \mathbf{\Lambda} \mathbf{v}^* = \sum_{\lambda}^m |u\rangle^{\lambda} \mathbf{\Lambda}^{\lambda} \langle v|^{\lambda}$$

$$\langle u^{\lambda} | u^{\lambda'} \rangle = \langle v^{\lambda} | v^{\lambda'} \rangle = \delta^{\lambda \lambda'}$$

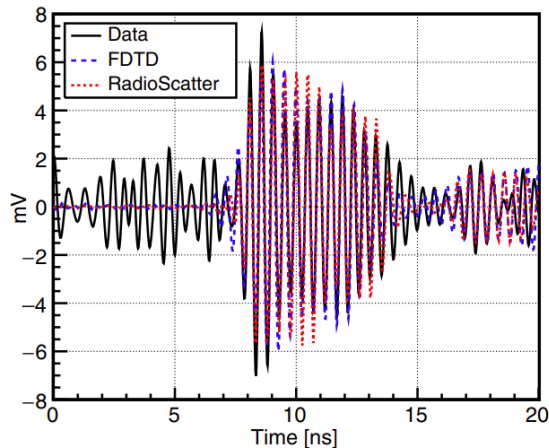
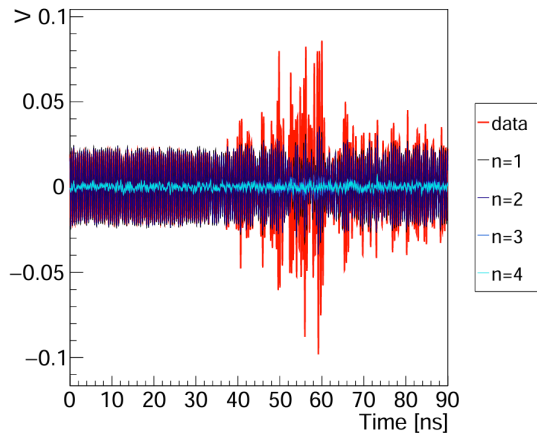
[3, 1]

Filtering with SVD

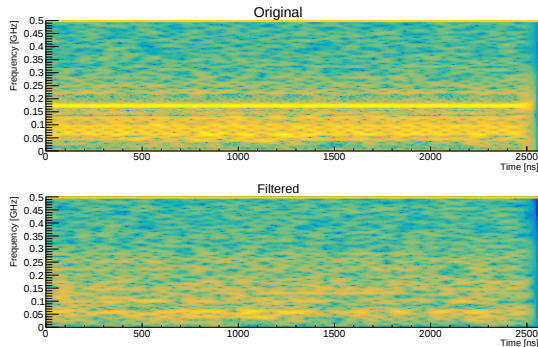
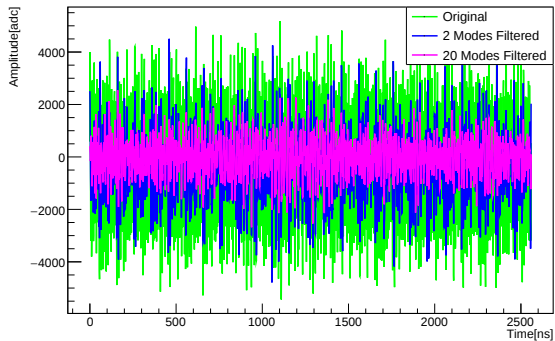


$$|E\rangle^{\text{filt}} = |E\rangle - \sum_{\lambda} |u\rangle^{\lambda} \langle u^{\lambda}|E\rangle$$

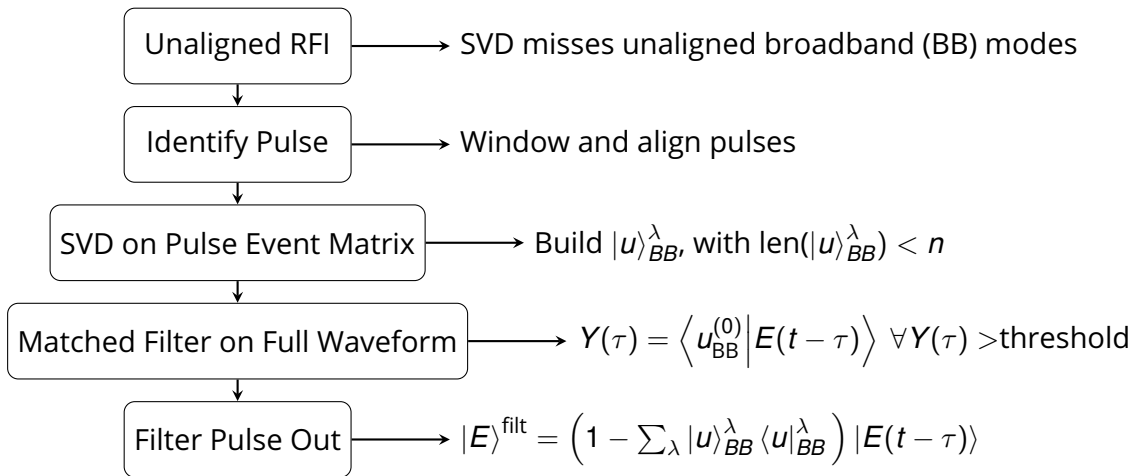
Weak Signal Extraction



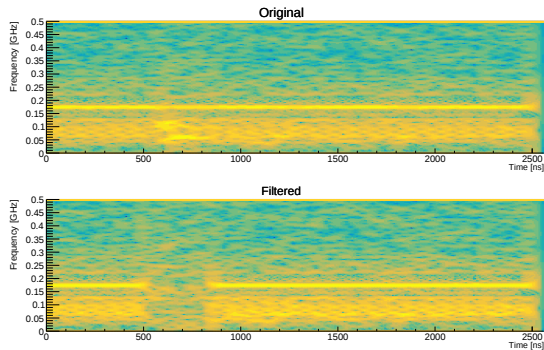
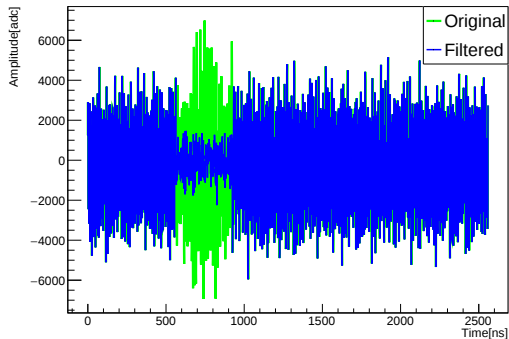
Standard SVD Applied to Skala Data



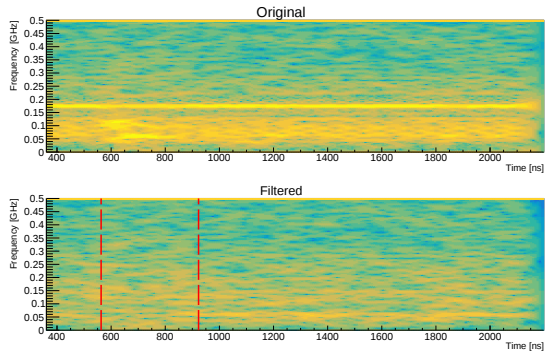
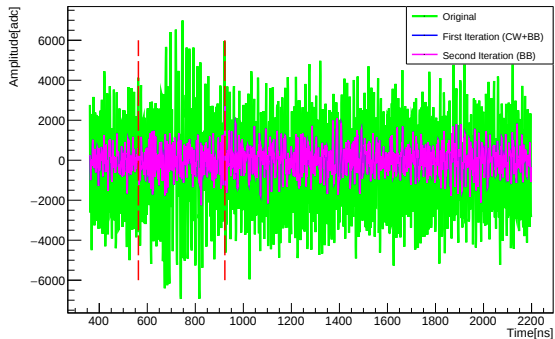
Matched Filter SVD



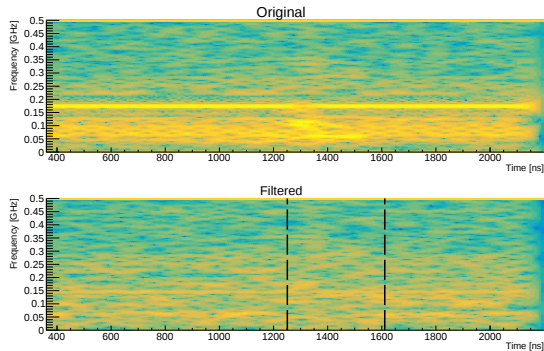
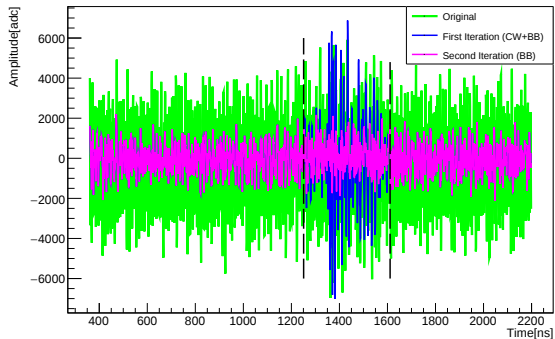
Matched Filter SVD



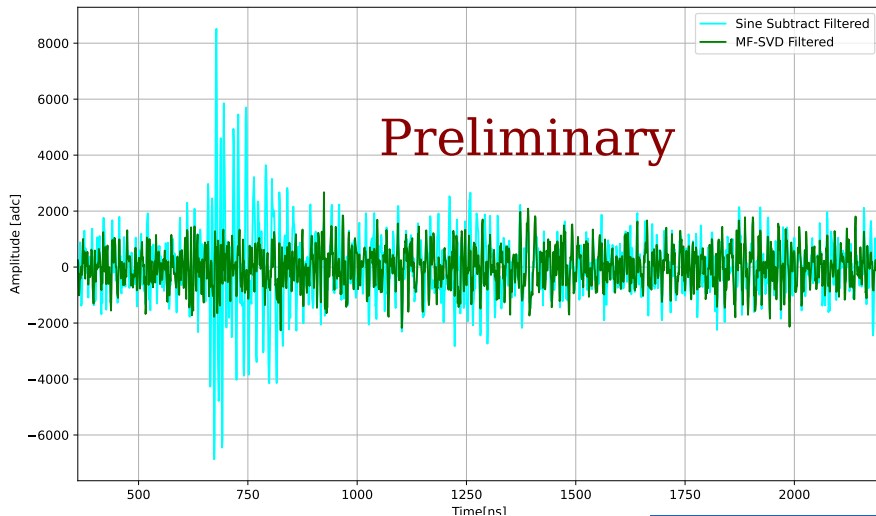
Matched Filter SVD



Iterated Matched Filter SVD

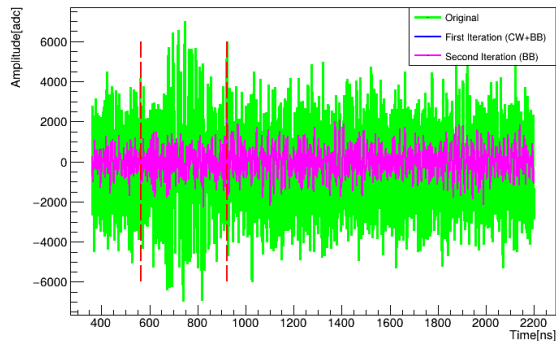


Compared To Sine Subtract



Conclusion

- The Radar Echo Telescope is a pathfinder experiment for a future radar-based neutrino telescope
- A sub-threshold analysis will combine ML and classical tools
- Matched-Filter Singular Value Decomposition shows promise at recovering low SNR signals
- Next Steps: Apply to full SKALA dataset, and apply to Radar Data



Acknowledgments



P. Allison, J. Beatty, D. Besson, A. Connolly, A. Cummings, C. Deaconu, S. De Kockere, K.D. de Vries, D. Frikken, C. Hast, E. Huesca Santiago, C.-Y. Kuo, A. Kyriacou, U.A. Latif, J. Loonen, I. Loudon, V. Lukic, C. McLennan, K. Mulrey, J. Nam, K. Nivedita, A. Nozdrina, E. Oberla, S. Prohira, J.P. Ralston, M.F.H. Seikh, R.S. Stanley, S. Toscano, D. Van den Broeck, N. van Eijndhoven, and S. Wissel



Curtis McLennan



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MADISON & LILA
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Questions?

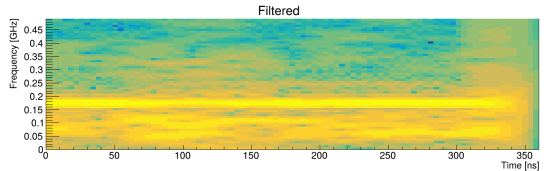
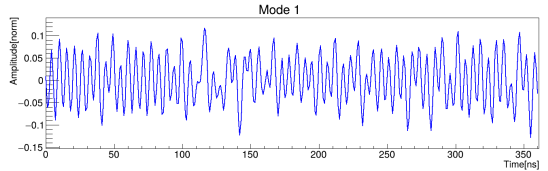
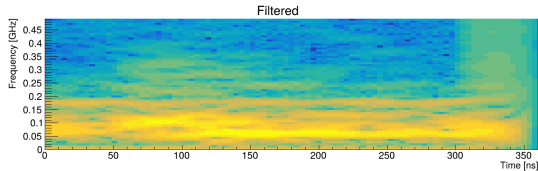
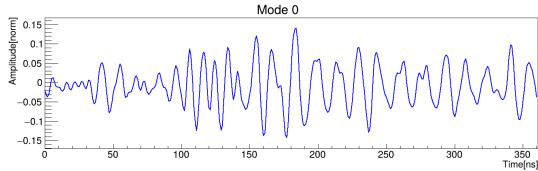


References I

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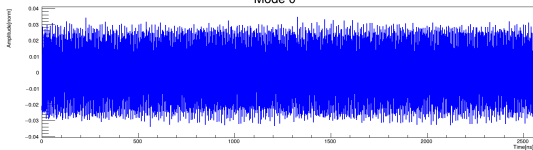
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Pulse Eigenmodes

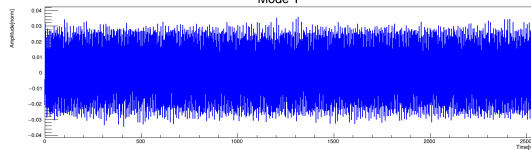


CW Eigenmodes

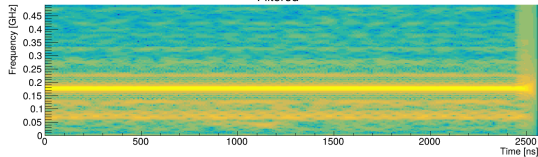
Mode 0



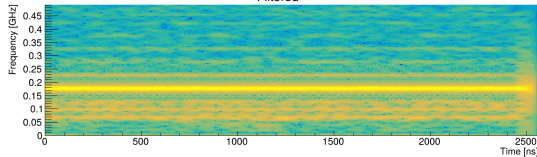
Mode 1



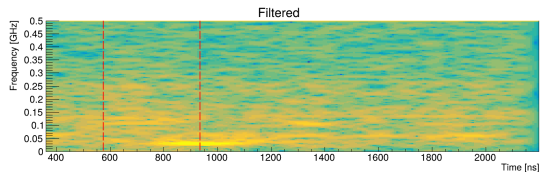
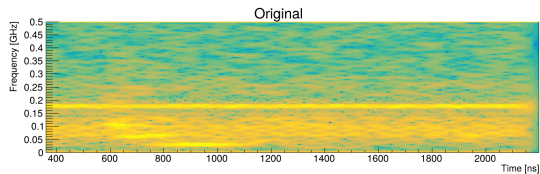
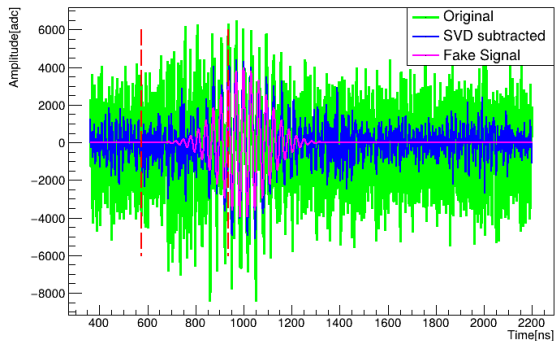
Filtered



Filtered

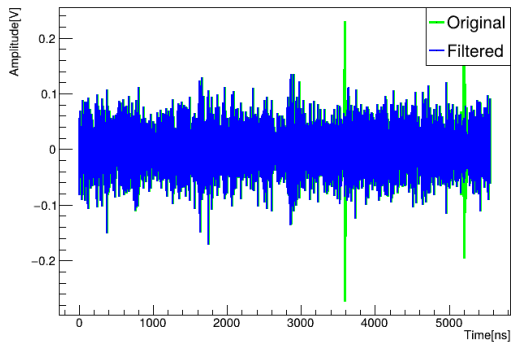


Example Signal extraction

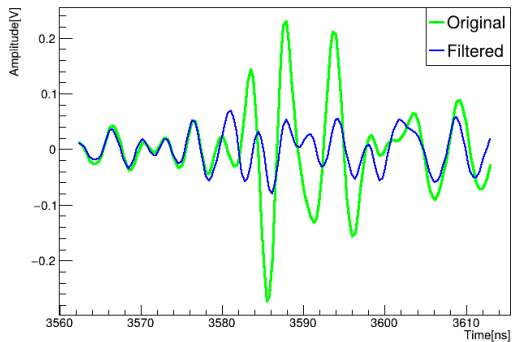


Chamber TX Blip Removal

Subtracted with Modes 0-2



Subtracted with Modes 0-2



RET TX-Blip Removal Algorithm

