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Lightning Radiometry in Visible and Infrared bands

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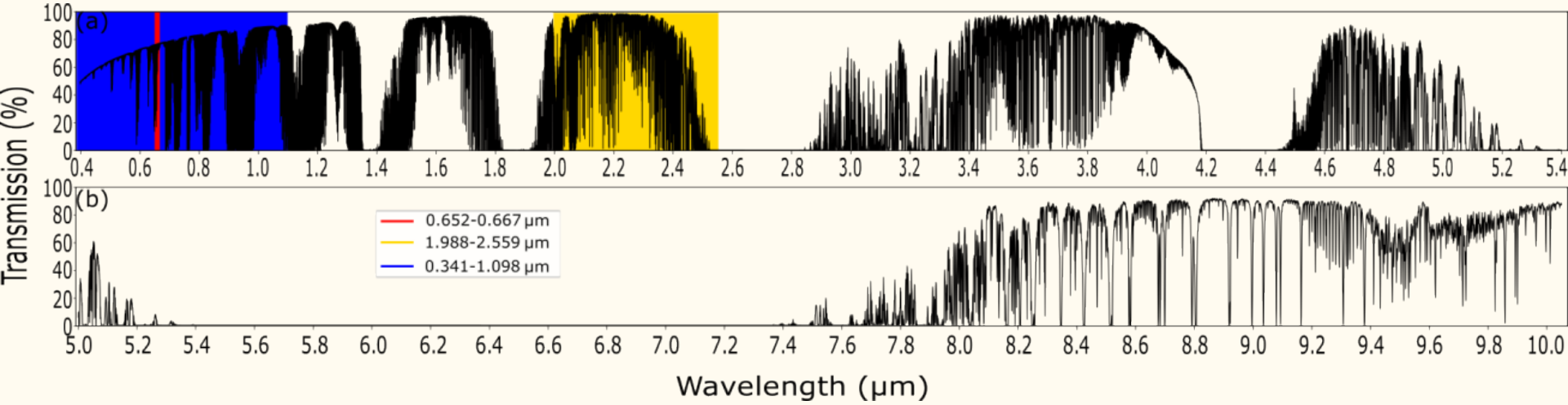
Outline

- Experimental data
- Radiometric calibration
- Earth Networks and cross-reference
- Sample pulse results
- Compiled data and prior work

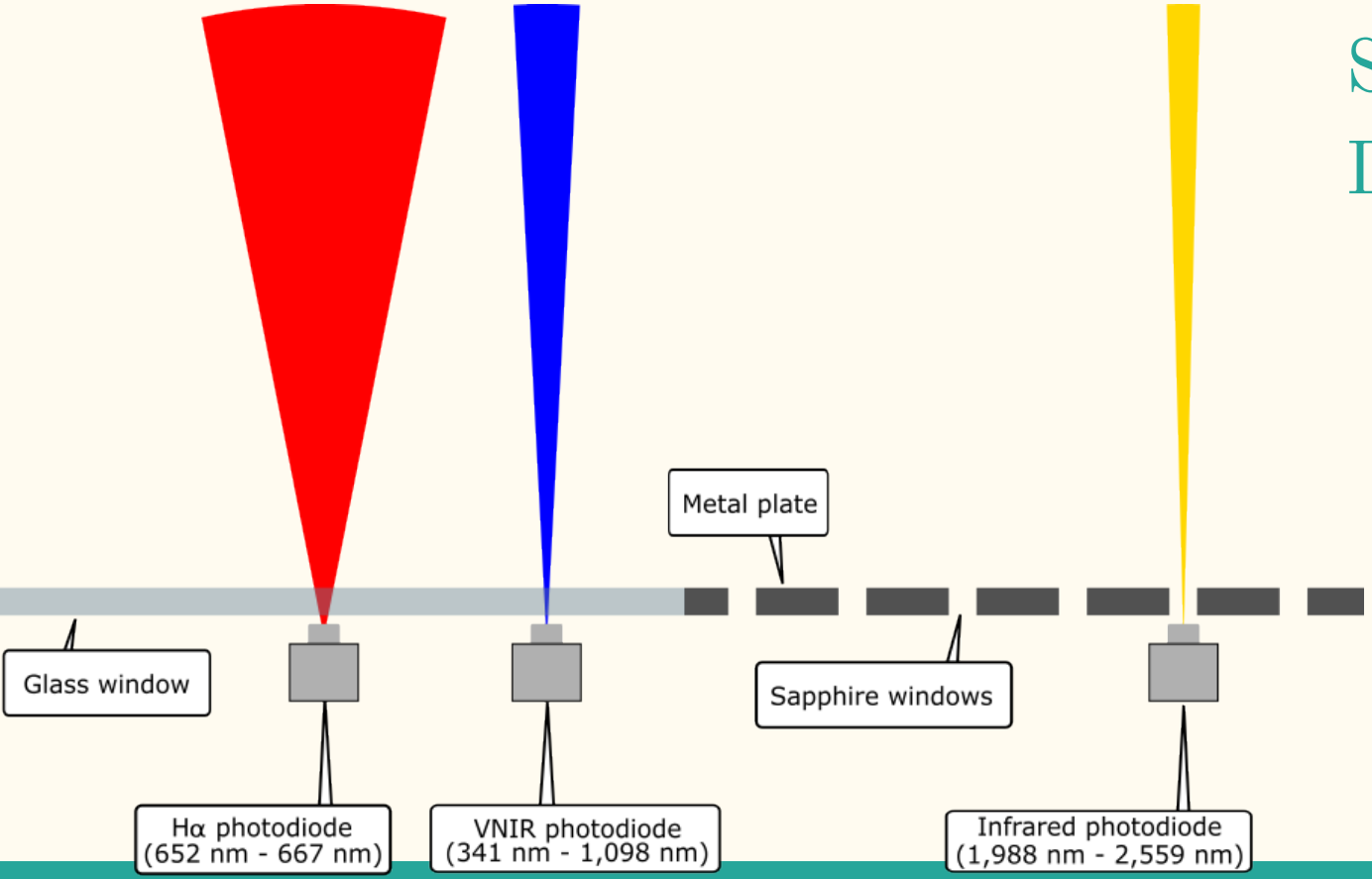
Experimental Data



Transmission through 10 km of atmosphere at an elevation of 3050 m (~10,000 ft)

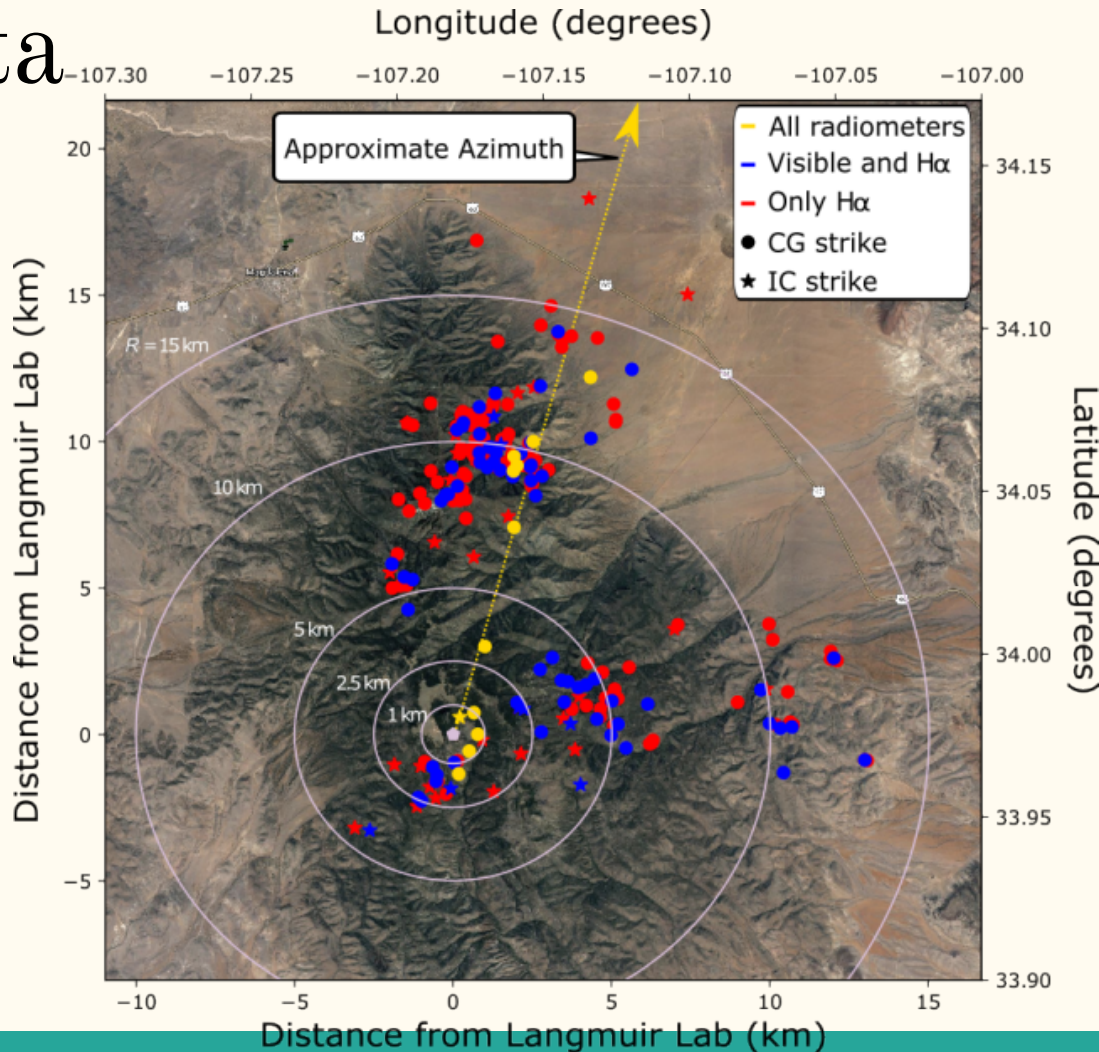
Experimental Data

Setup at Langmuir Lab



Experimental Data

Storm on August 10th



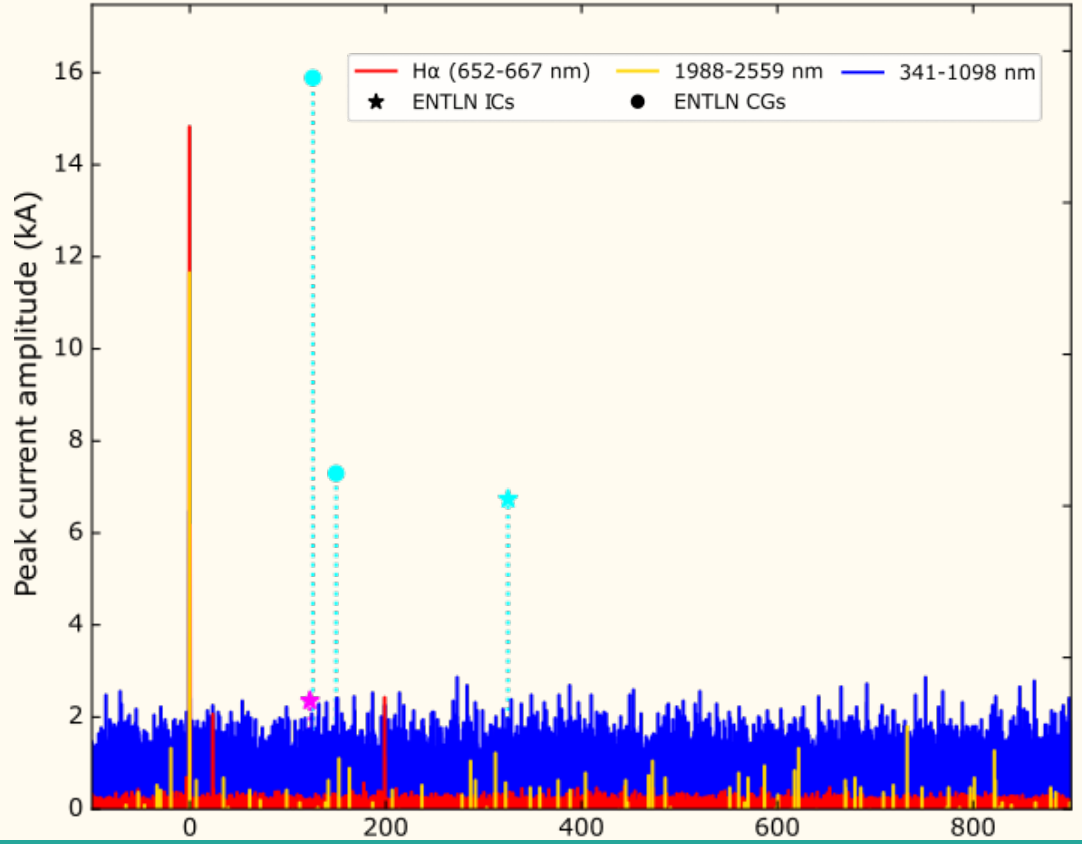
Radiometric Calibration

- Start with a known source power
- Filter diode to match the magnitude of the voltage in the experimental data
- Finalize with a linear approximation to get observed power

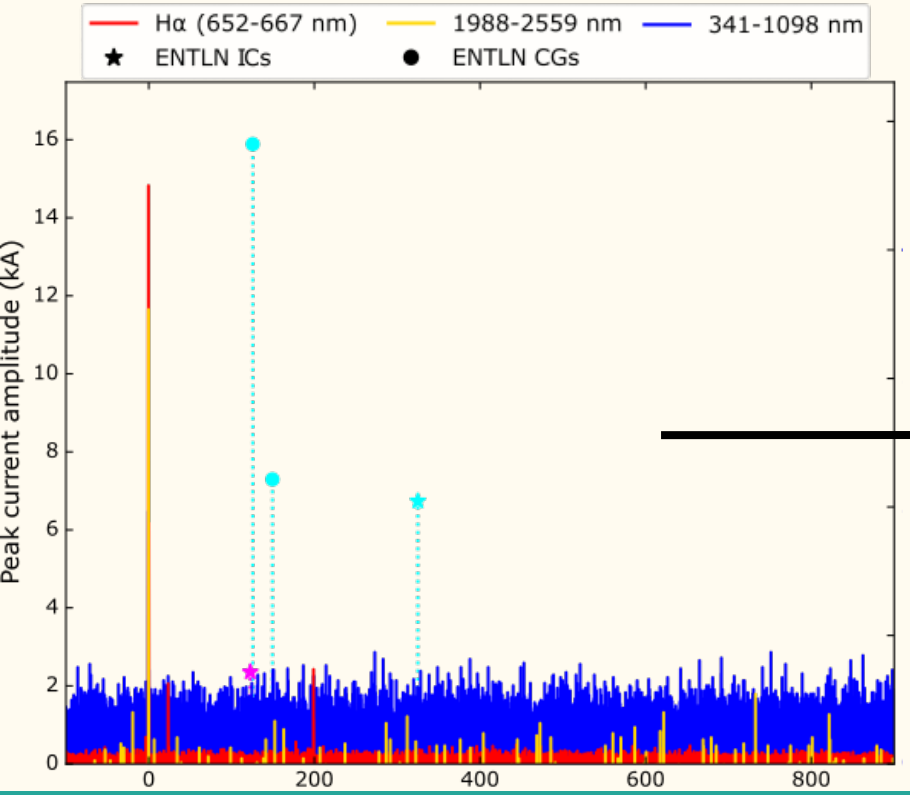
$$P_{source}(t) = \frac{4\pi P_{obs}(t)}{\Omega(r)T(r)}$$

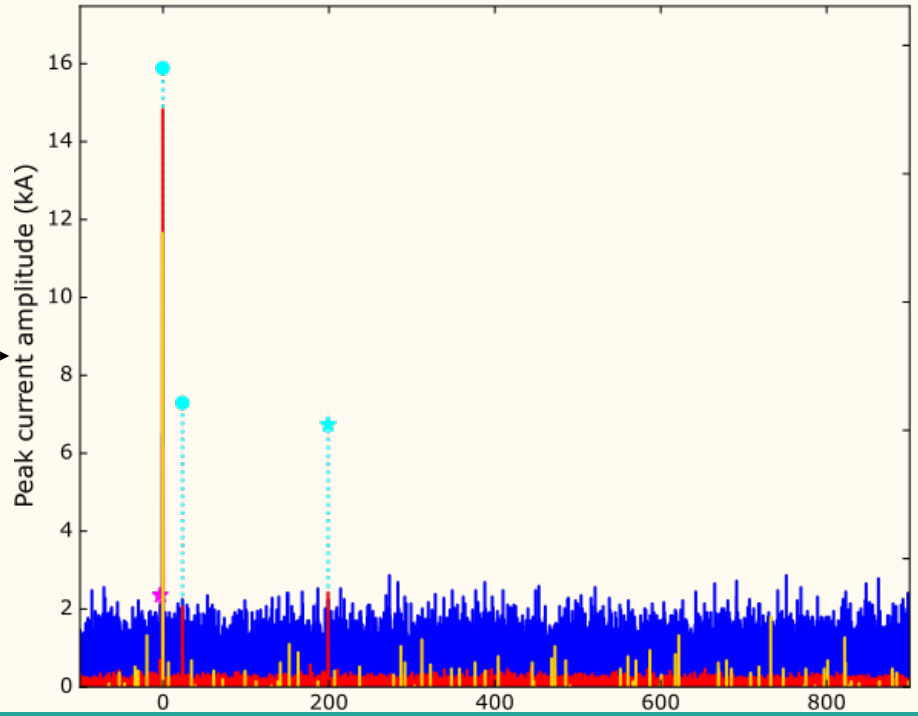
Earth Networks cross-reference

- Unaligned pulses
- Time difference between pulses maintained

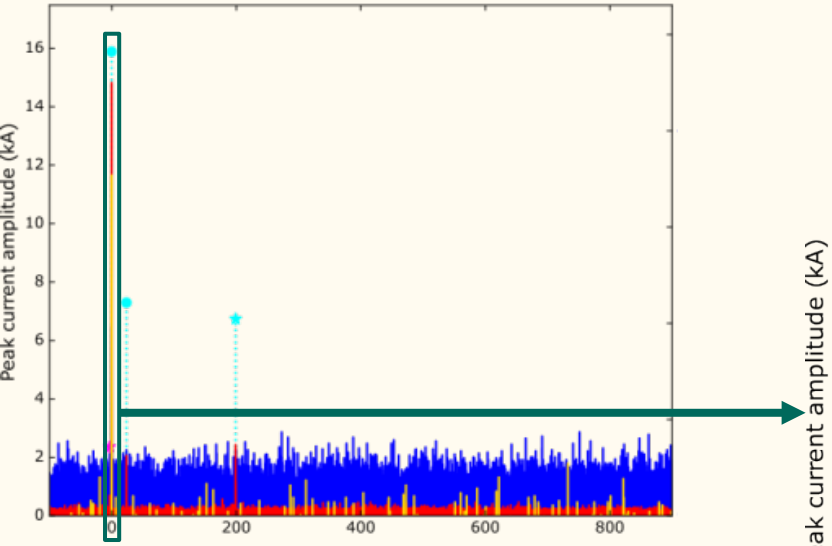


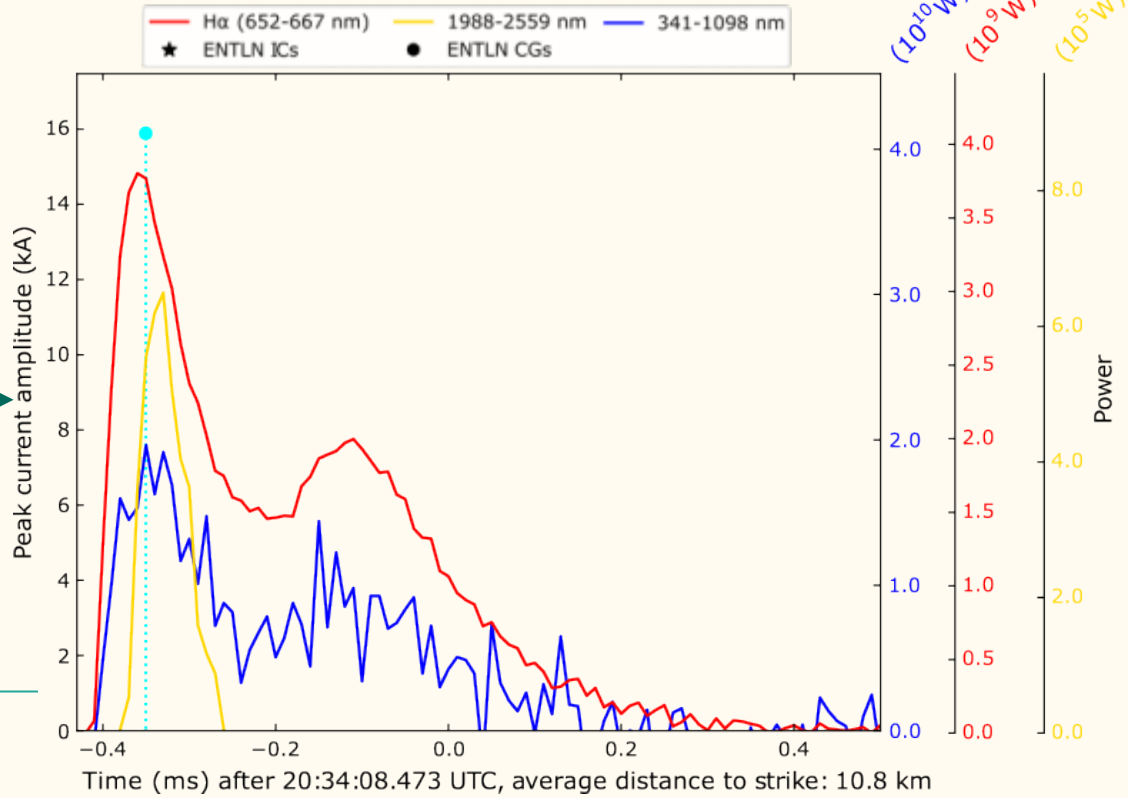
Earth Networks cross-reference





Sample pulse results





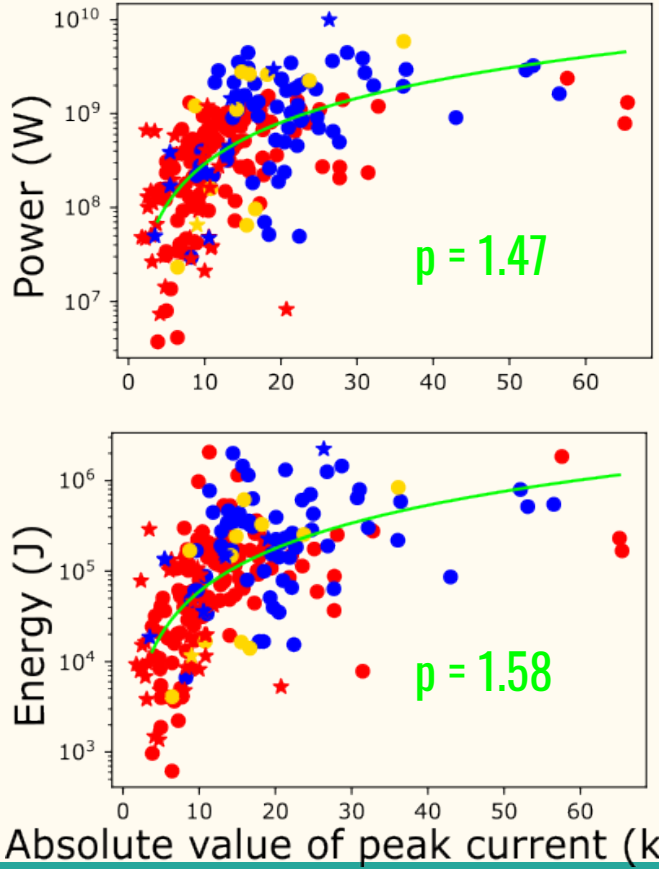
$$P_{source}(t) = \frac{4\pi P_{obs}(t)}{Q(r)T(r)}$$

Compiled Data and Prior Work

- Trendlines are power laws of the form:

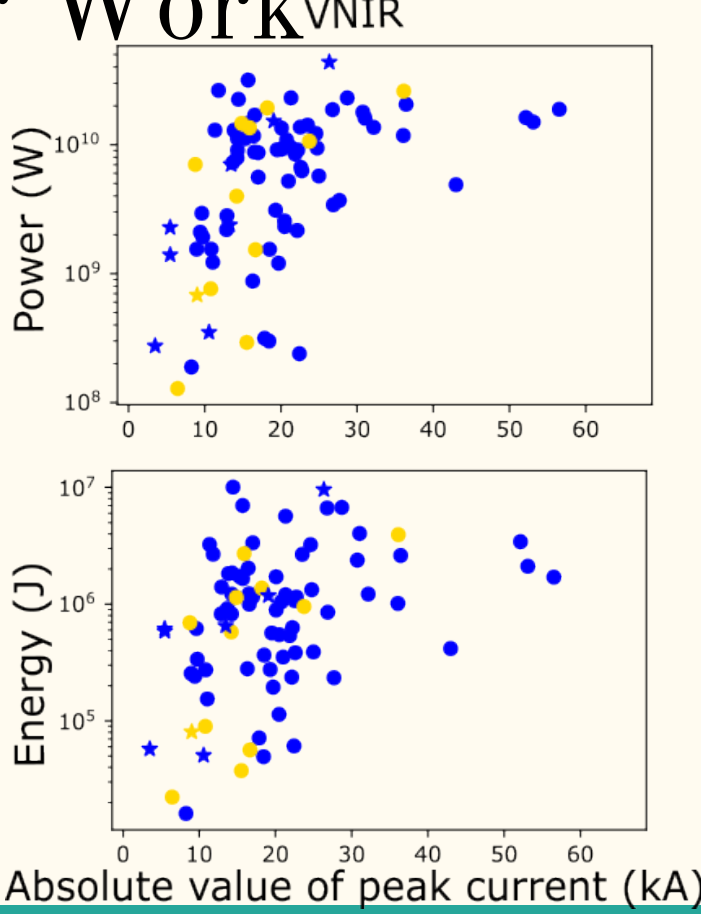
$$y \sim x^p$$

- Between a linear and quadratic fit



Compiled Data and Prior Work

- Median values for VNIR are 9.3±7.4 GW and 1.5±1.9 MJ
- Quick and Krider (2013) report median values at 18 GW and 3.6 MJ



Conclusions

- Some infrared ranges can be used to view the lightning return stroke
- Calibration methods should work for both infrared and VNIR photodiodes
- Radiometric data in the infrared bands can be compared to plasma models for temperature estimates
- These results have been submitted for publication in JGR: Atmospheres

Thank you!

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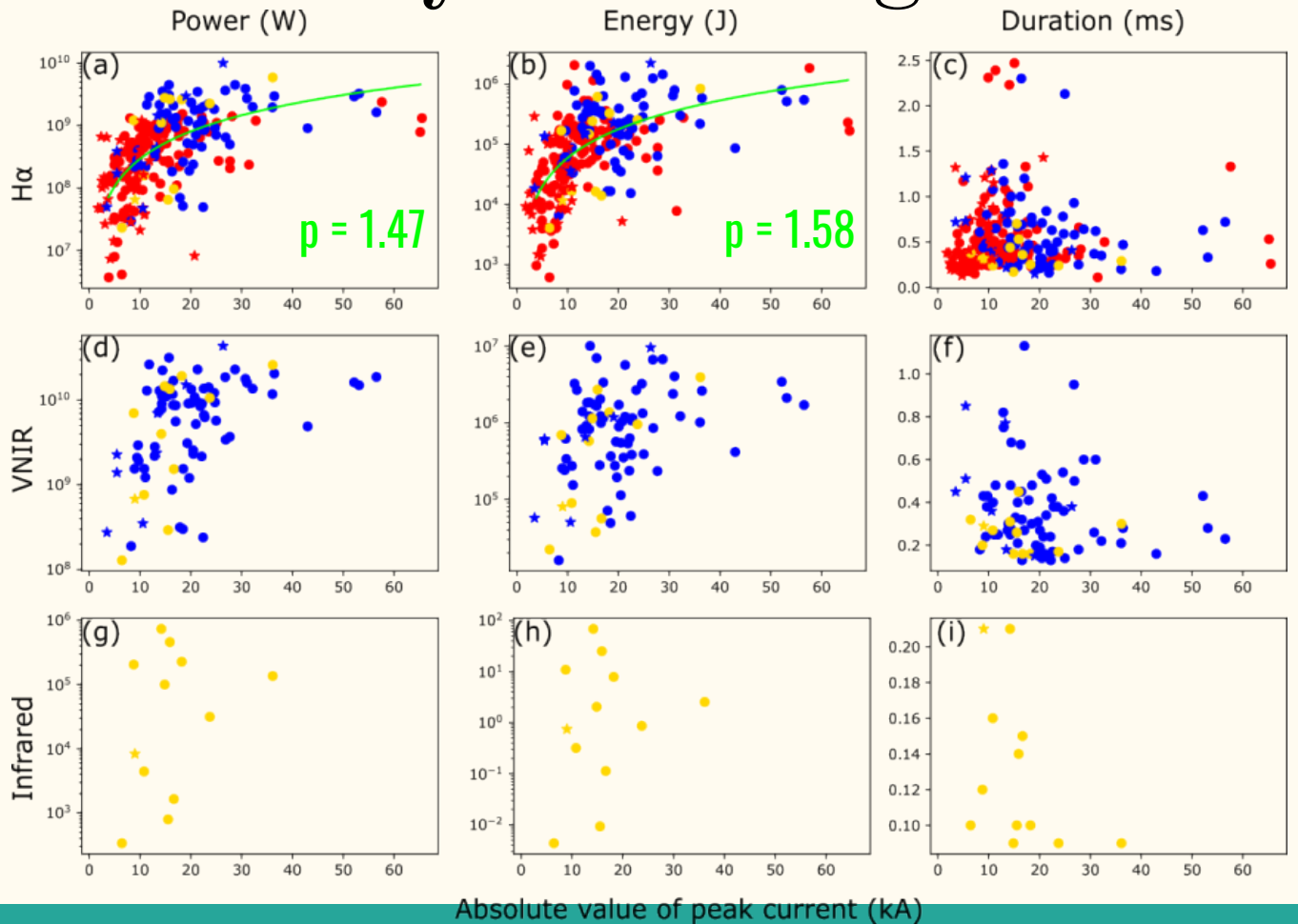
Extra Slides

Storm Summary - Full Figure



Storm Summary - Table

	Peak Current (kA)	Number	Power (W)	Energy (J)	Duration (ms)	Power Ratio
(a) Entire data set						
H_α		235	$8.2\pm11\times10^8$	$2.1\pm3.5\times10^5$	0.56 ± 0.40	0.16 ± 0.04
VNIR	14.7 ± 10.3	84	$9.2\pm8.3\times10^9$	$1.5\pm2.0\times10^6$	0.35 ± 0.20	1
Infrared		12	$1.6\pm2.2\times10^5$	9.9 ± 19	0.13 ± 0.04	$2.5\pm4.9\times10^{-5}$
(b) −CGs only						
H_α		193	$8.7\pm9.8\times10^8$	$2.2\pm3.3\times10^5$	0.55 ± 0.41	0.16 ± 0.04
VNIR	15.6 ± 9.5	75	$9.3\pm7.4\times10^9$	$1.5\pm1.9\times10^6$	0.34 ± 0.19	1
Infrared		11	$1.7\pm2.2\times10^5$	11 ± 20	0.12 ± 0.04	$2.6\pm5.1\times10^{-5}$

Table 1. Optical properties measured with radiometers in three different bands. Section (a) includes data from CGs and ICs of both polarities, while section (b) shows results exclusively for −CGs. Quantities are given as a mean plus or minus standard deviation. The last column shows the ratio of the power measured by that instrument to the power measured by the broadband visible radiometer.

Detector Responsivity