FEGS Validation Analysis

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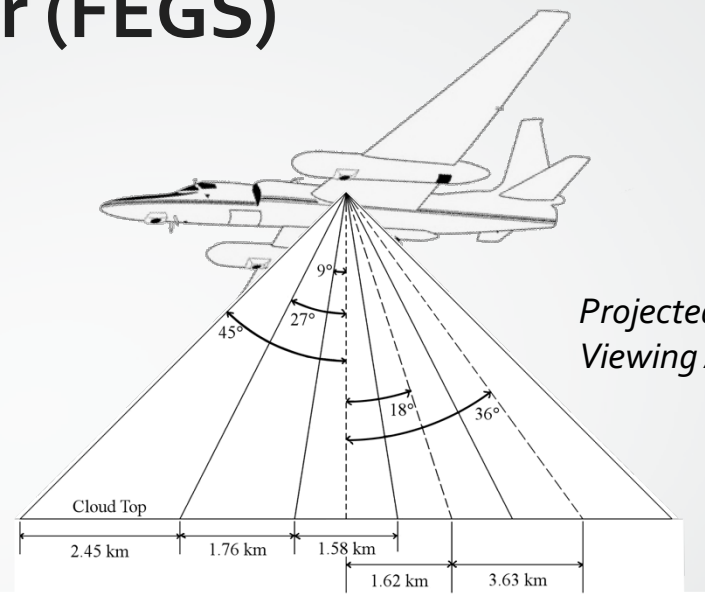
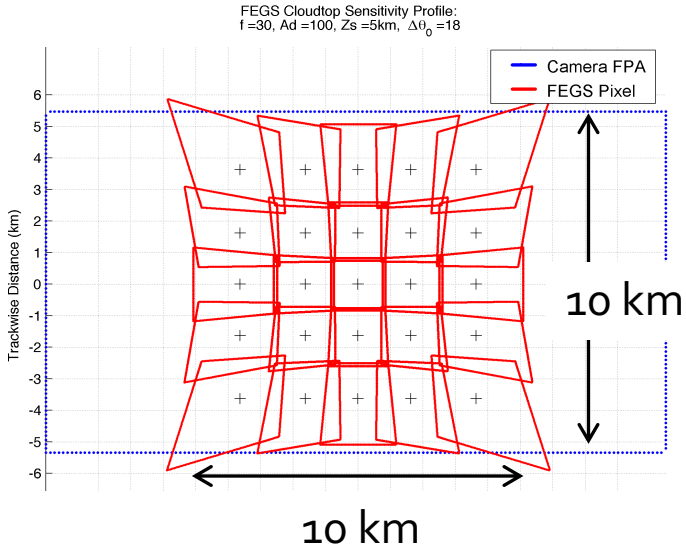
Fly's Eye GLM Simulator (FEGS)

- Array of 30 radiometers
  - 5 x 5 main radiometer
  - 777 nm OI emission;
  - 5 additional spectral
- 1080p Digital Video Camera
- 10x10 km footprint at cloud-top;
- 2x2 km nominal resolution;
- 100 kHz sample rate

- *Optical to Optical comparison*



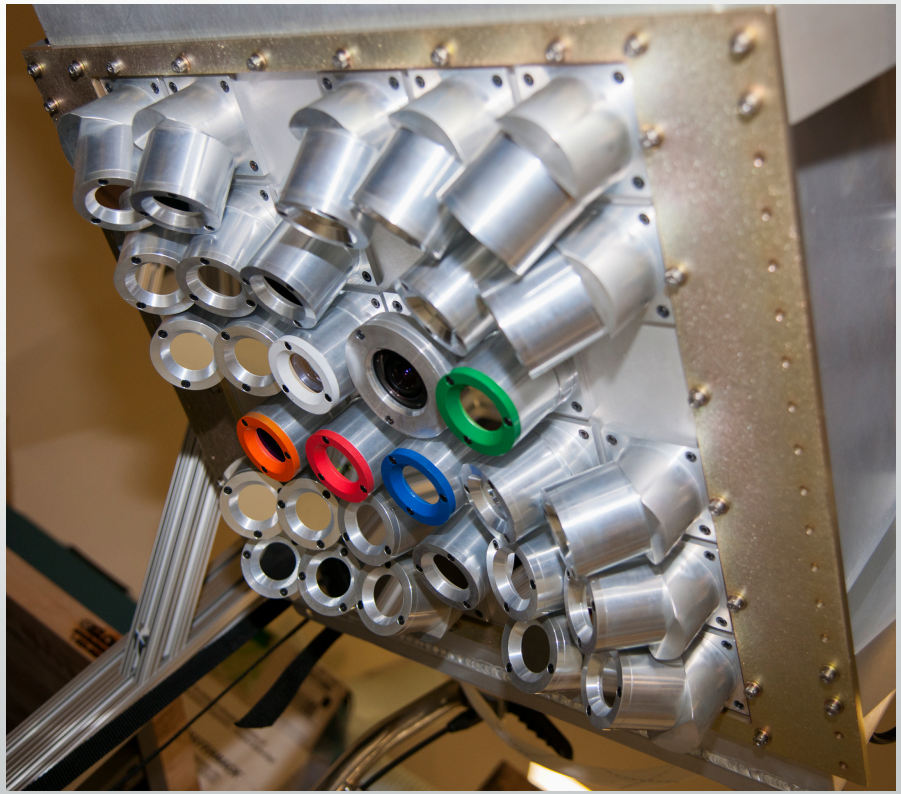
Projected FEGS Viewing Angles



FEGS Footprint

Objectives

- Determine GLM Flash Detection Efficiency / False Alarm Rate
- Validate the GLM events while observing the same storms
  - location accuracy in space and time
- Provide calibration of the Optical Energy that is observed by the GLM
  - Background radiance (day/night)
  - Signal radiance



Field Campaign Data

ECRS DATA-MANUAL
16 -> 15
XTK R 34.9
TKE R 145.0
D 35.8/T 5.1
NASA

GOES-R Validation Field Campaign

FEGS Collection Summary

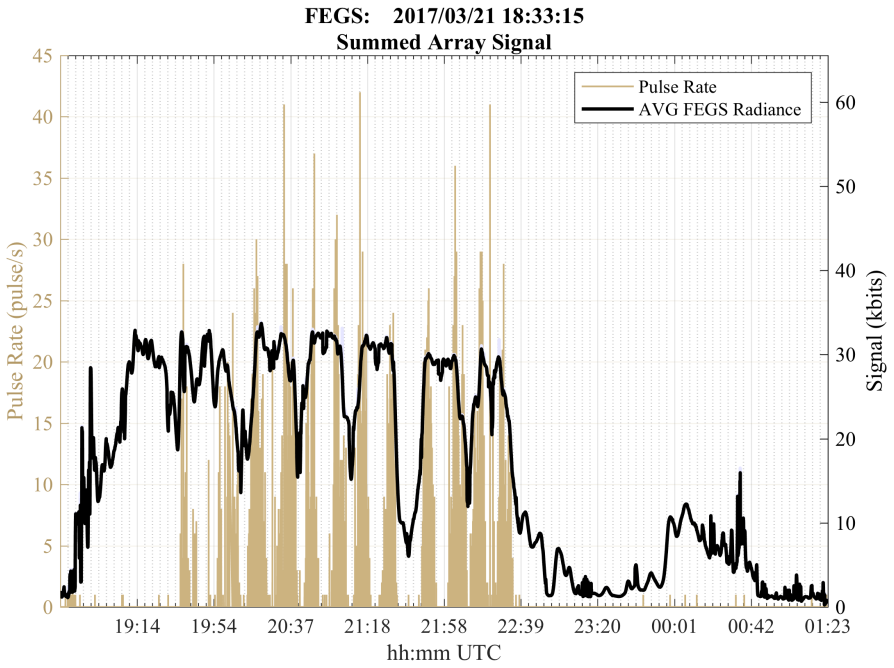
FLY'S EYE
GLM SIMULATOR

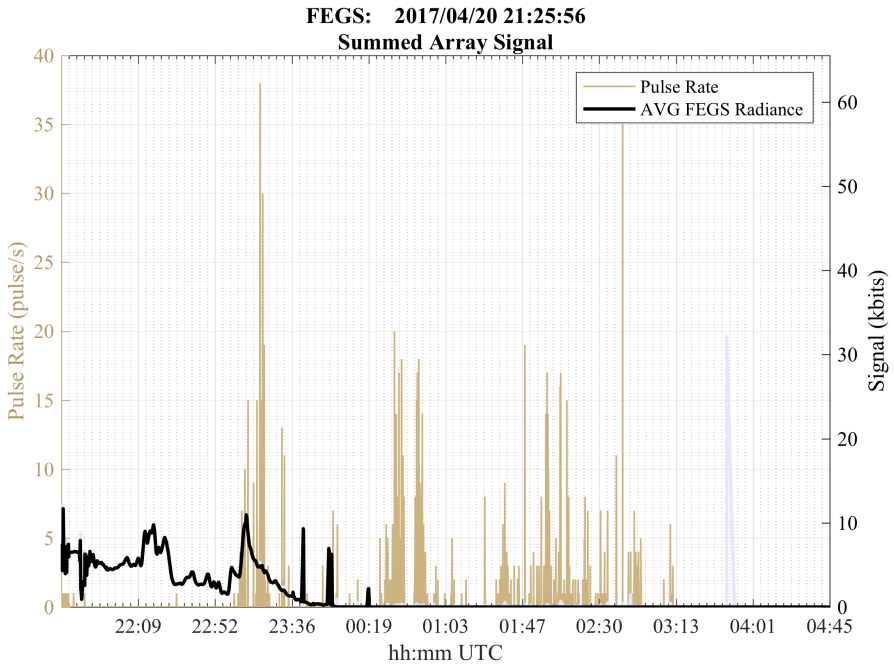
DATE	Location	Data Size	Pulse Count	Flash Count	Time
2017/03/21	California	148 GB	11418	1370	Day
2017/03/23	Sonora	-		-	
2017/03/28	Sonora	-		-	
2017/04/11	Transit	-		-	
2017/04/13	Gulf of Mexico	-		-	
2017/04/16	Oklahoma	171 GB	1039	308	Night
2017/04/18	Huntsville	138 GB	853	200	Day
2017/04/20	Toronto	157 GB	1461	324	Night
2017/04/22	Huntsville	130 GB	8546	1317	Dusk
2017/04/27	Huntsville	120 GB	291	19	Night
2017/04/29	Oklahoma	173 GB	4846	890	Night
2017/05/07	Florida	-		-	
2017/05/08	Colorado	200 GB	7485	1195	Dusk
2017/05/12	Louisiana	153 GB	5551	773	Day
2017/05/14	KSC/Atlantic	186 GB	2344	381	Day
2017/05/17	Oklahoma	178 GB	3356	563	Night
	TOTAL	**1.75 TB**	**47190 Pulses**	**7340 flashes**	**4 Day, 5 Night, 2 Dusk**

U2 Flights (1980s)
1300 Pulses
79 flashes

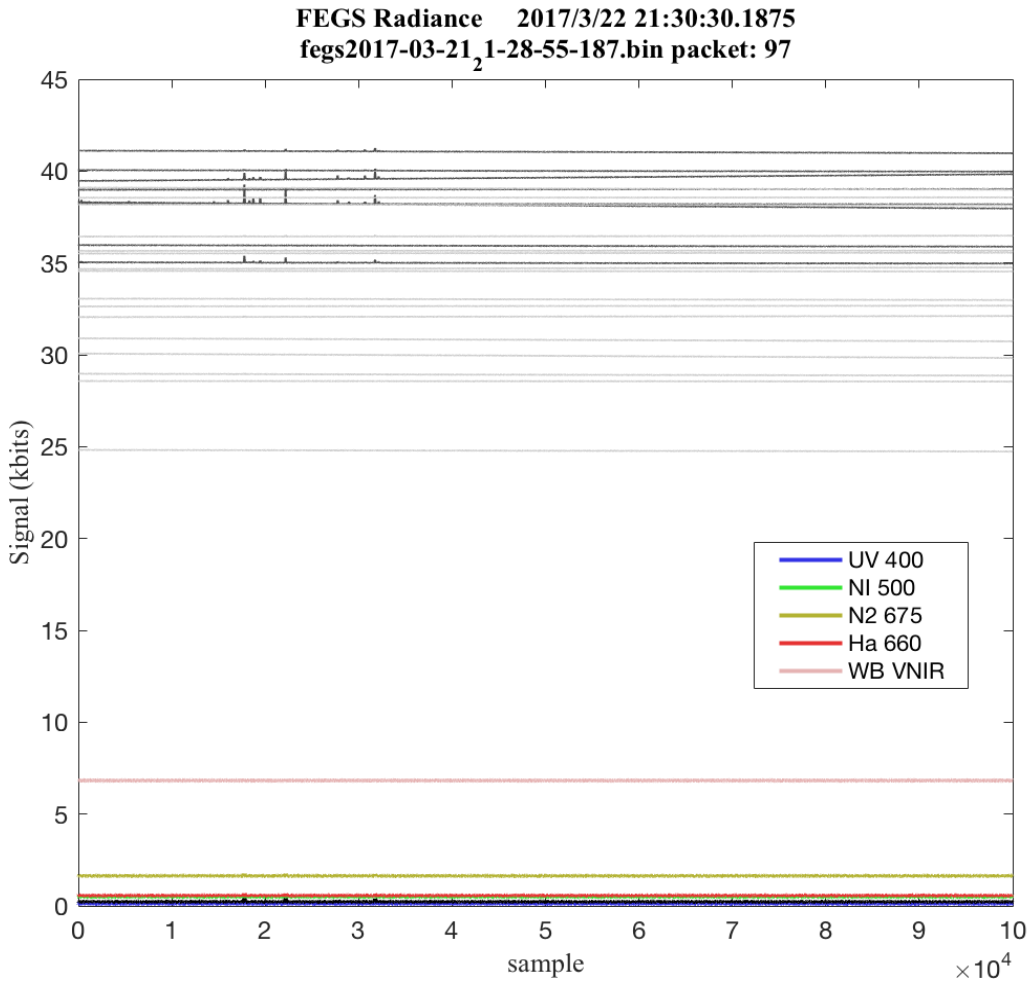
Altus Cumulus Electrification Study (2002)
5256 pulses
587 flashes

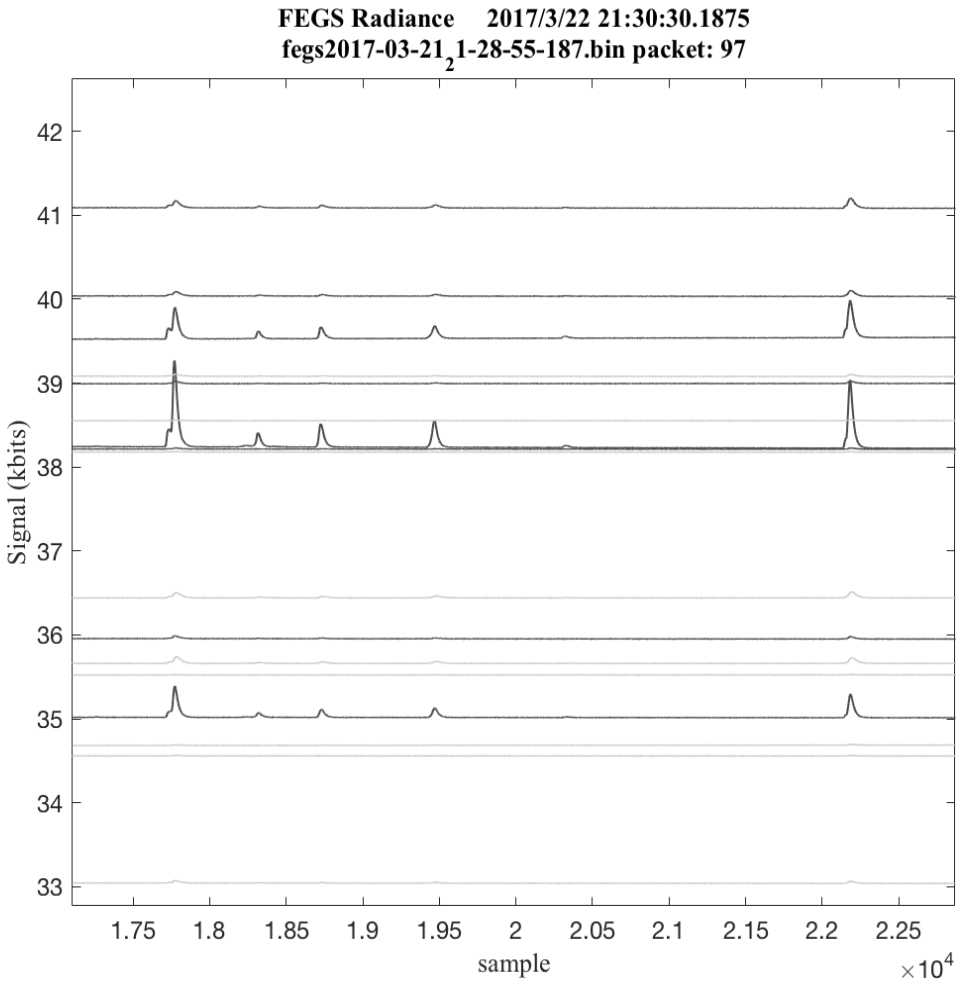
Flight Summaries



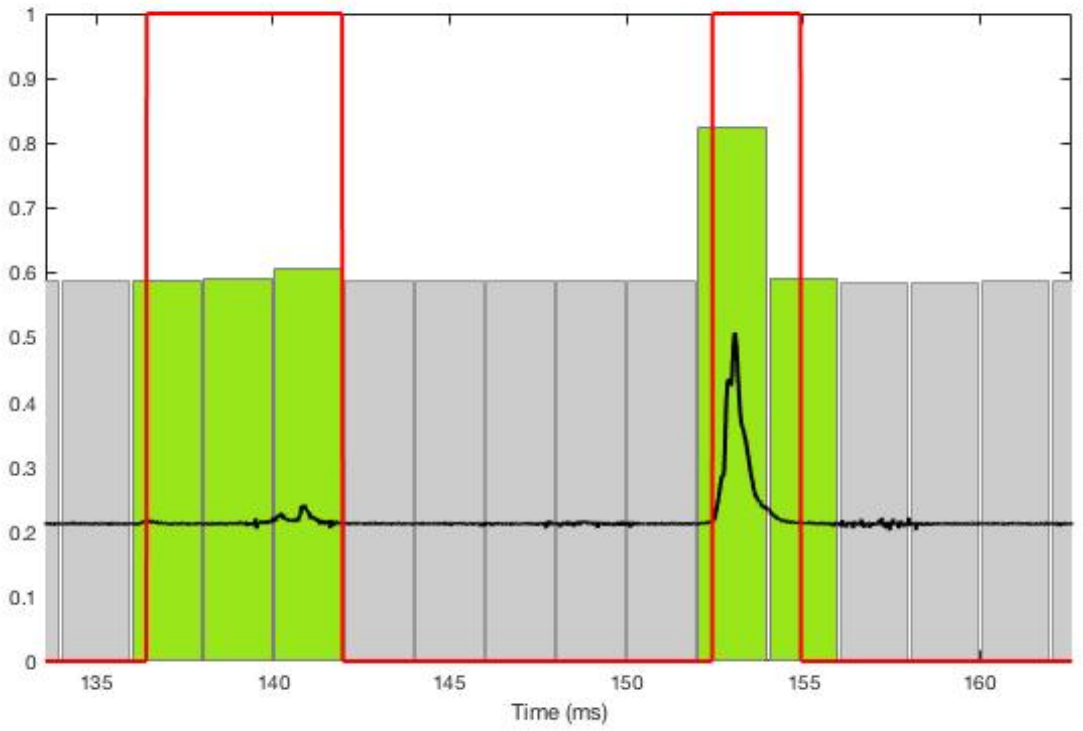


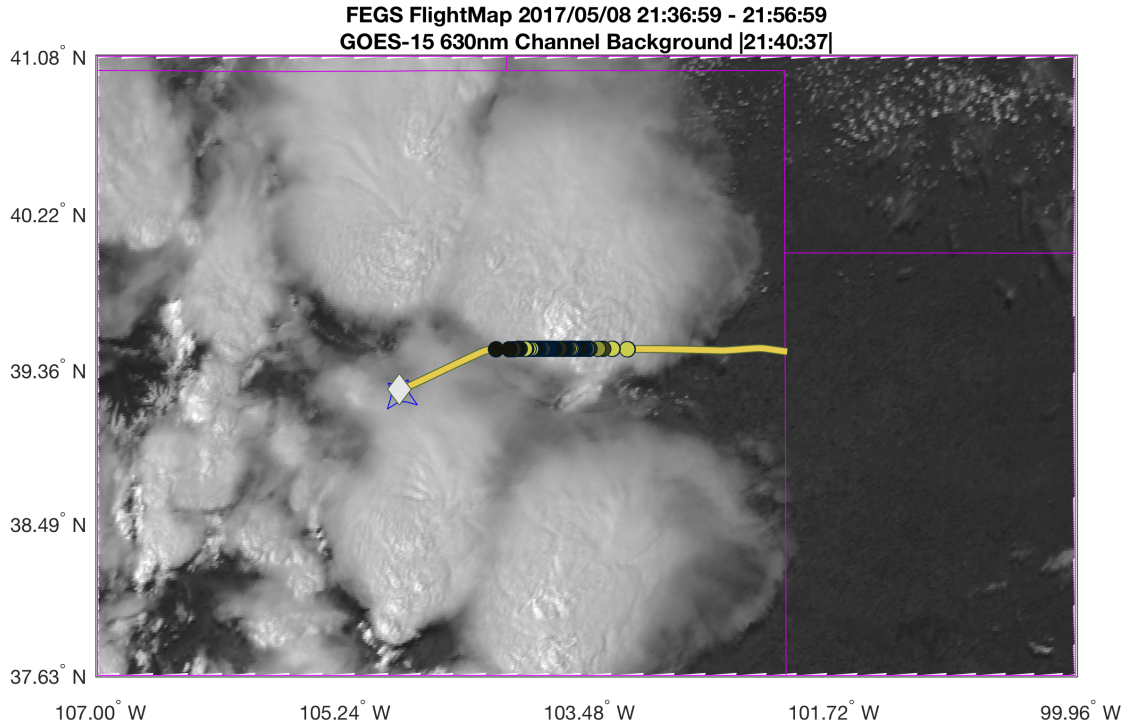
Waveform Data





FEGS GLM Proxy





FEGS Data Example:

Black – optical signature

Red – detected optical pulse

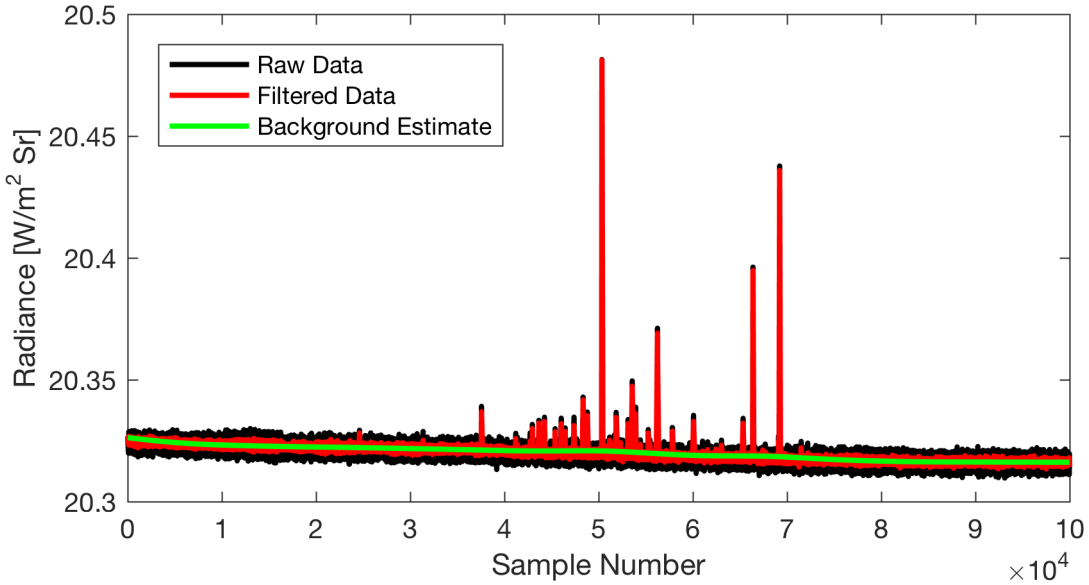
Grey – 2 ms integrated energy

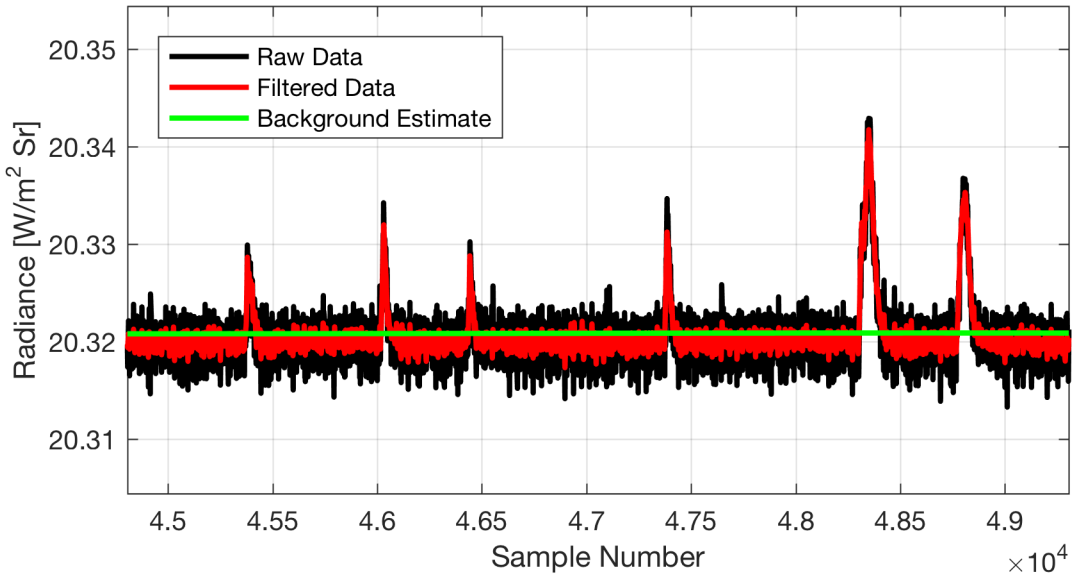
Green – 2 ms 'event' detection

Storm overpass on May 8th over Colorado. Circles show FEGS detected lightning flashes.

FEGS Version 1

- Pulse Data
- Flash Data derived from Pulse Data
- Signal Processing
- Parameters


Raw Data
Filtered Data
Background Estimate
Radiance [W/m^2 Sr]
Sample Number
$\times 10^4$


Raw Data
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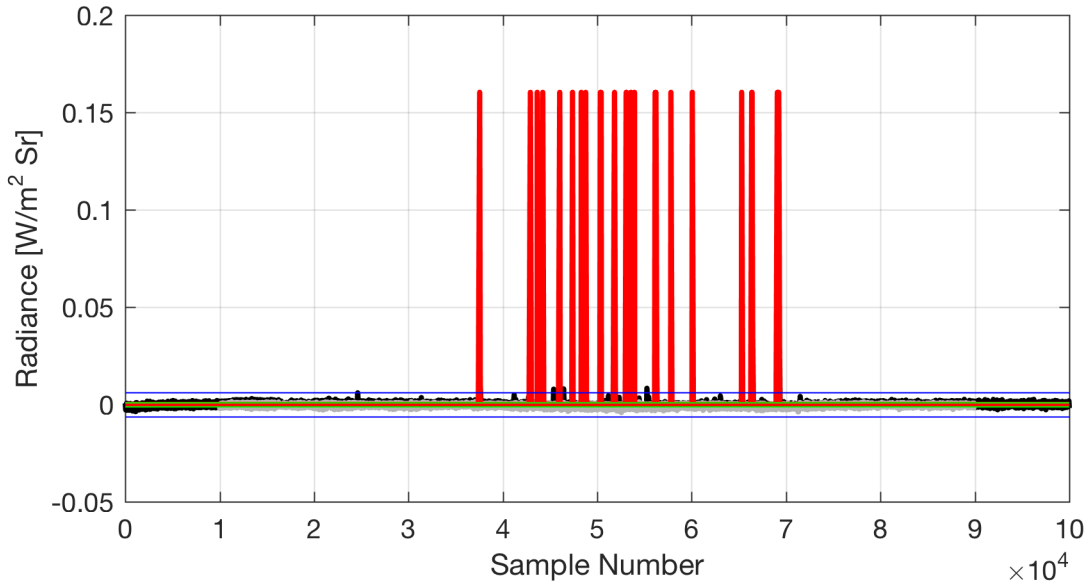
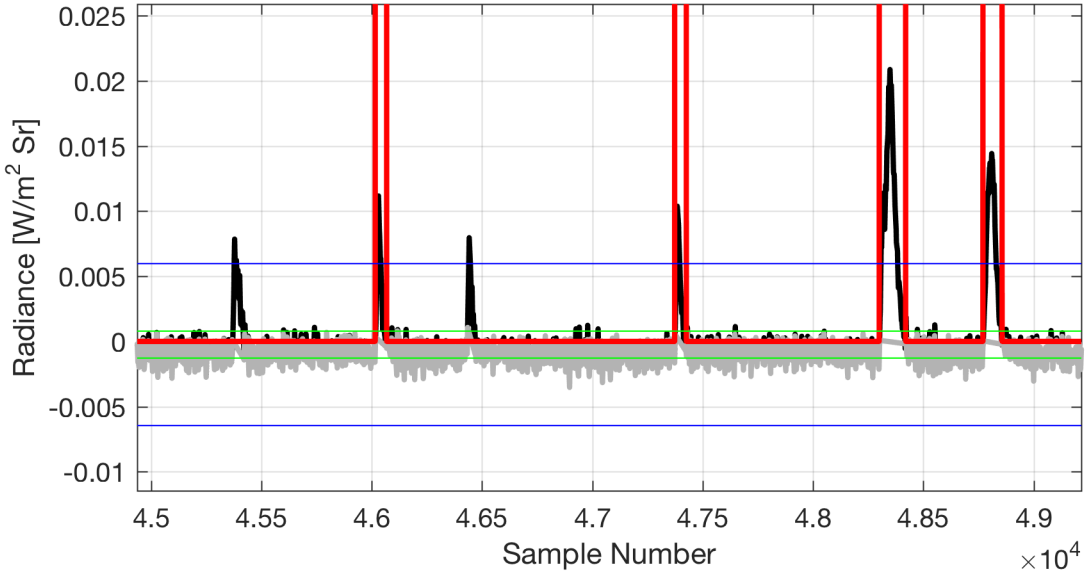
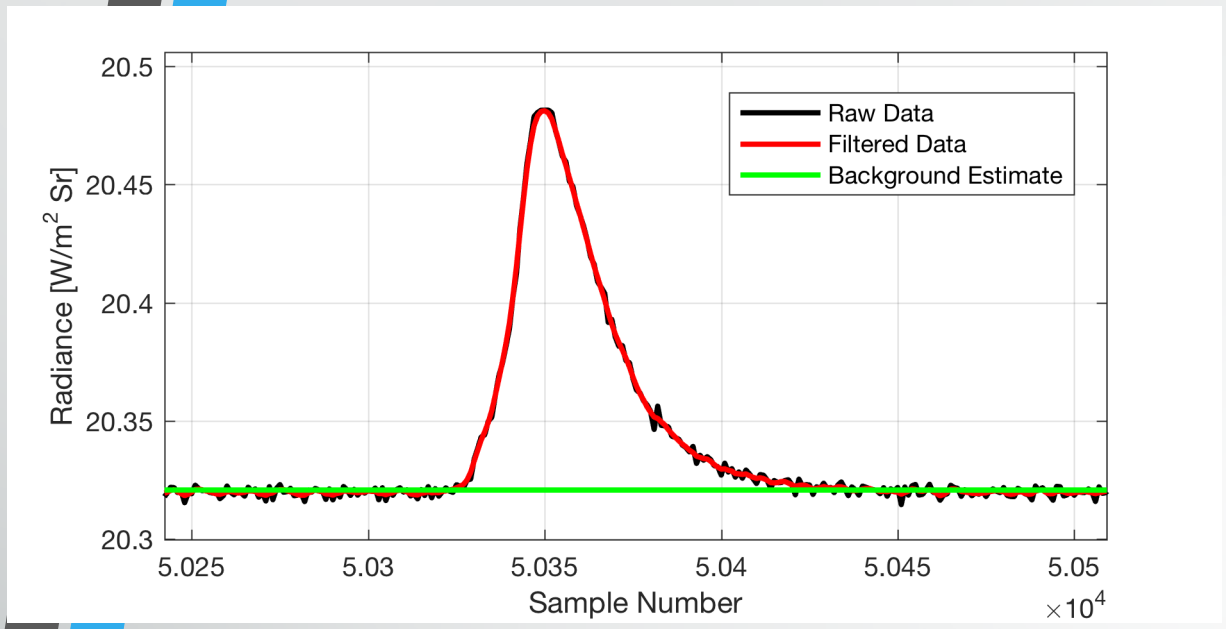
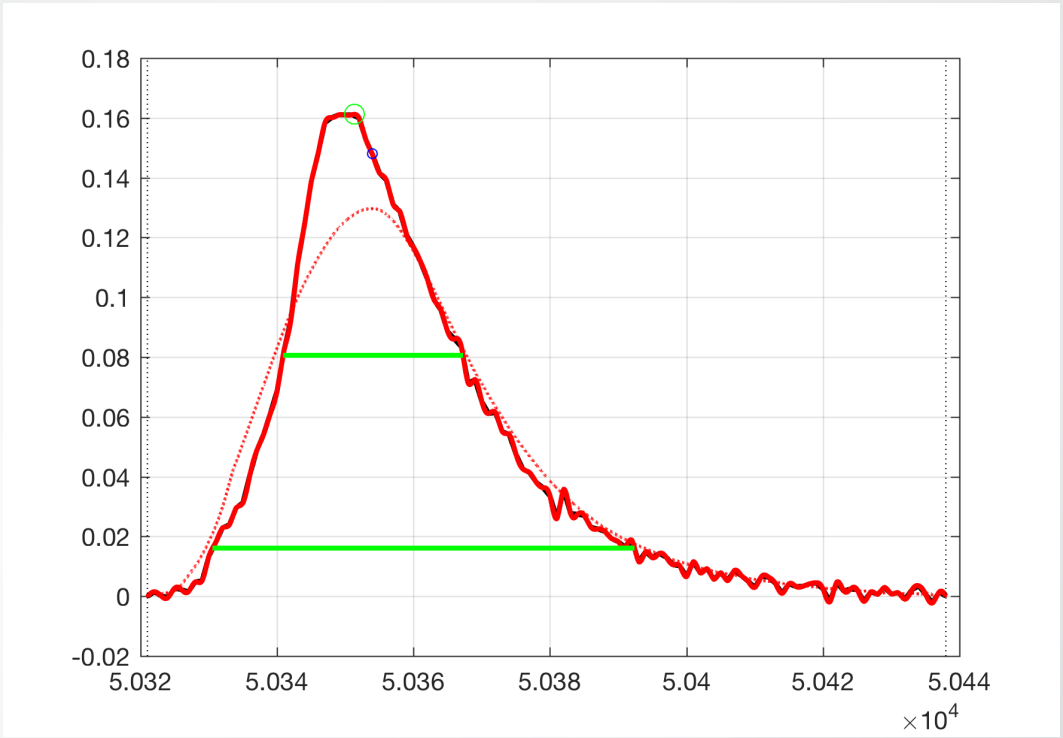
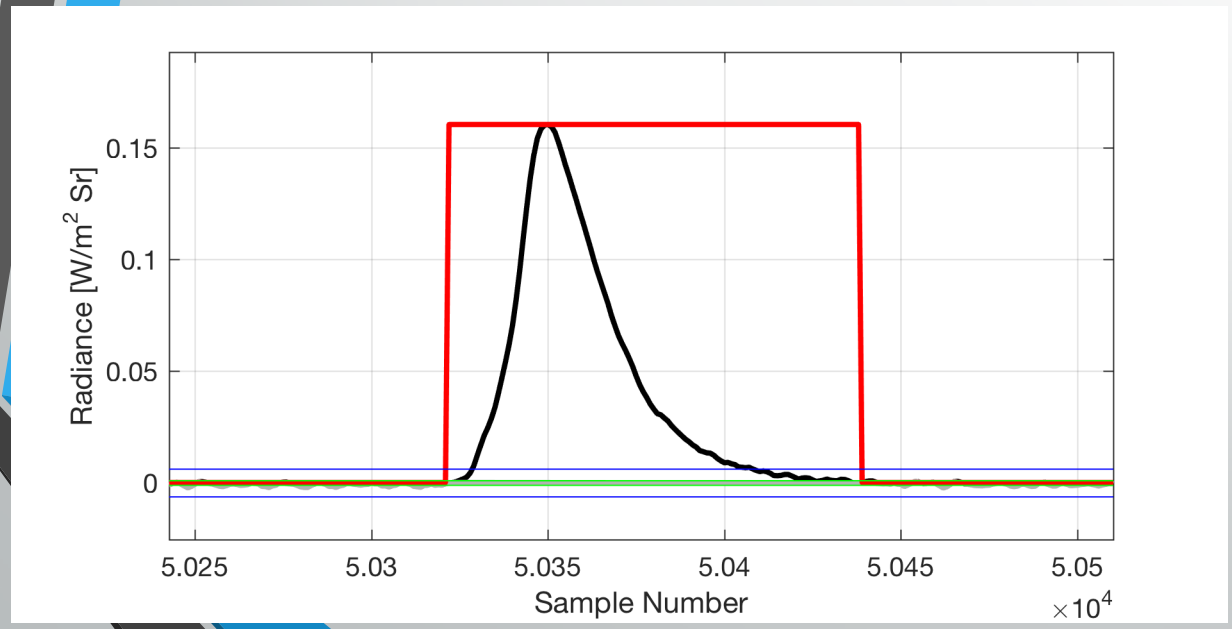

Radiance [W/m^2 Sr]
Sample Number
$\times 10^4$


Radiance [W/m^2 Sr]
Sample Number
$\times 10^4$







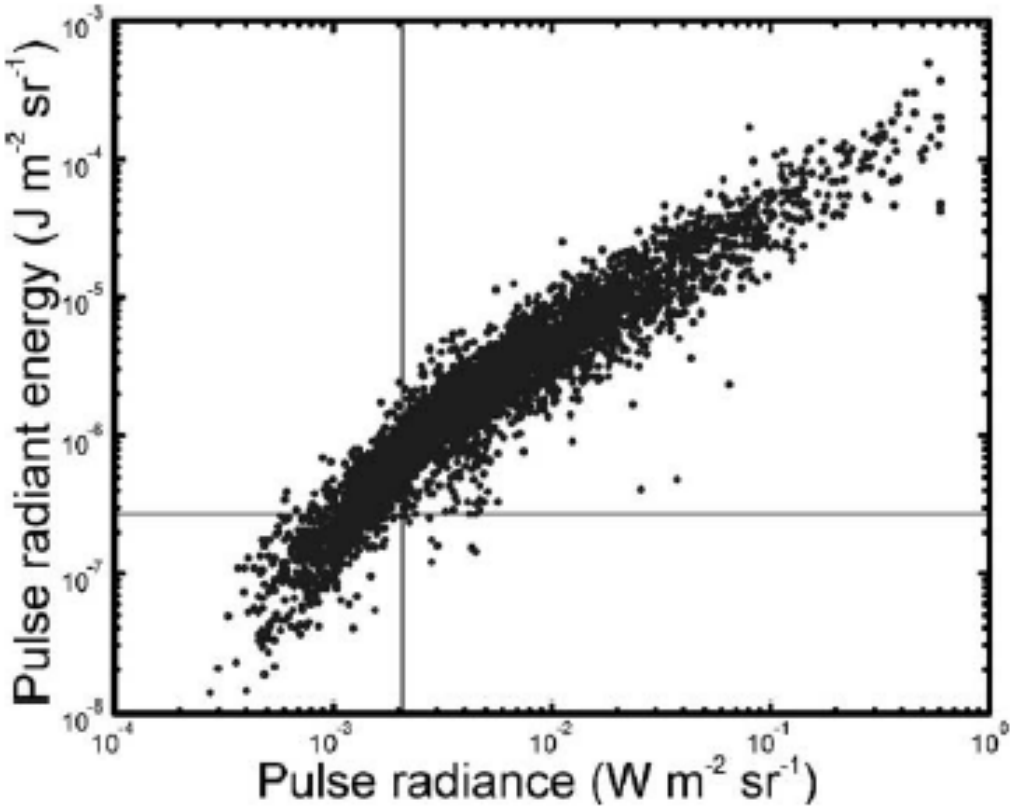
- Pulse Start Time
- Pulse End Time
- Lat, Lon, Alt, Roll
- FOV Projection

- Peak Radiance
- Radiant Energy
- Pulse Duration
- 10-90% rise time
- 10-10% width
- 50-50% width
- Background Radiance
- Signal to Noise

Limitations

- Lower Threshold… More False Pulses
- Background Variation vs Continuing Current difficult to separate
- Computationally Expensive…
  - Only summed array radiance in version 1

Pulse Power and Energy



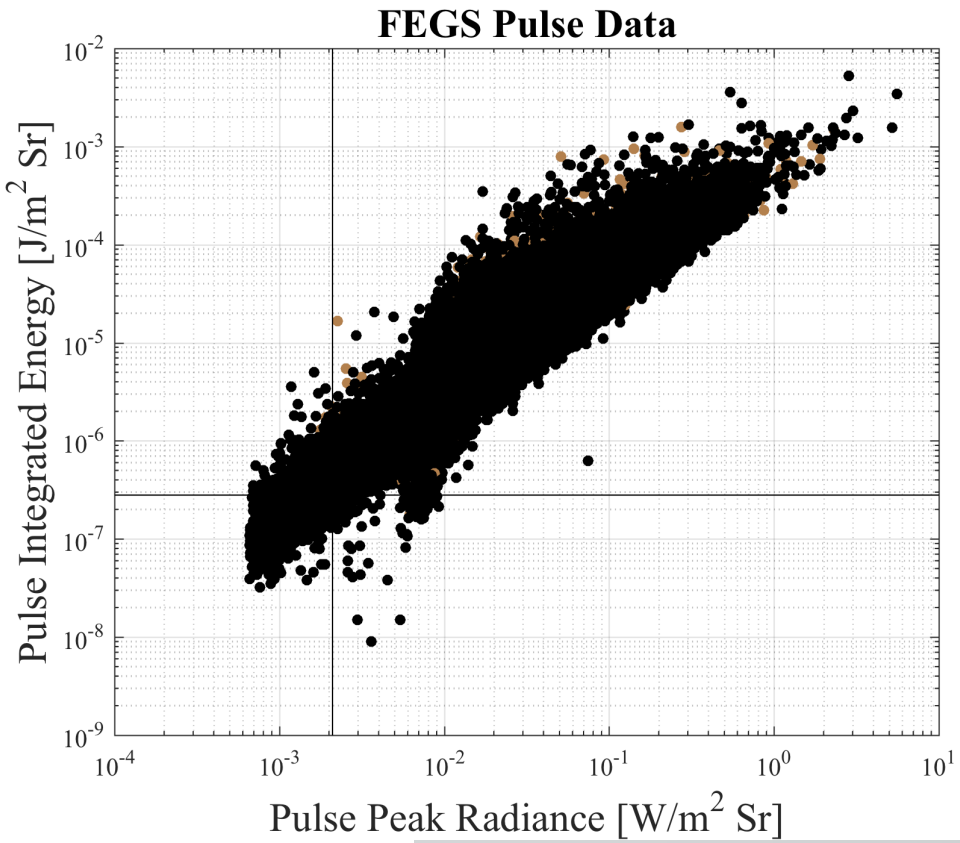
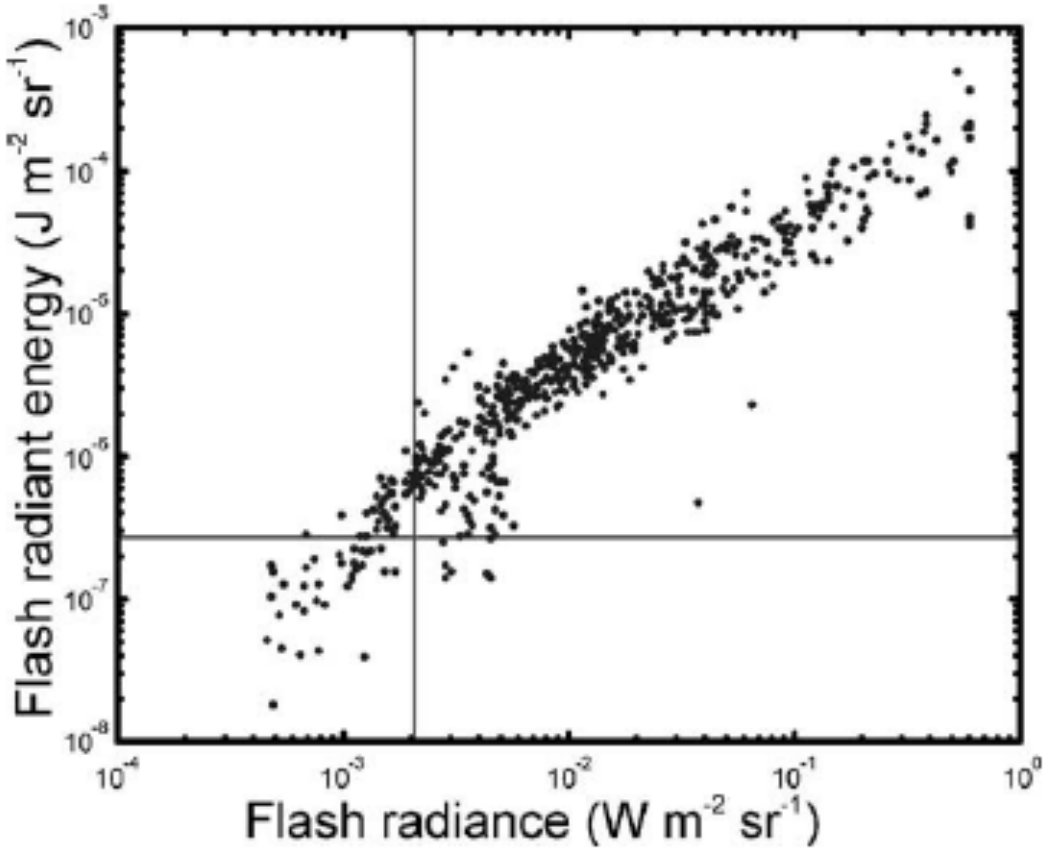
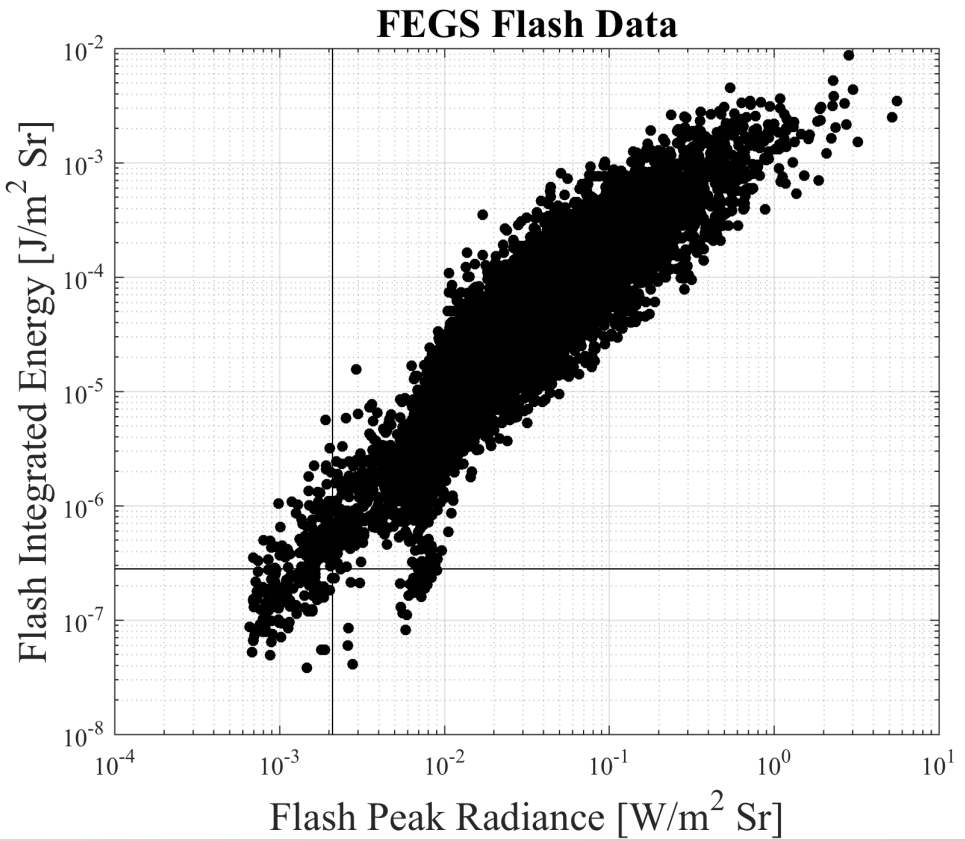


Fig. 10. Power vs. energy for simple pulses. The minimum radiance of the Goodman et al. (1988) U2 data, corresponding to 2.1 mW m^{-2} sr^{-1}, is shown as a vertical line on this plot. The horizontal line in this plot corresponds to the minimum energy observed during the U2 study (0.28 μJ m^{-2} sr^{-1}).

Flash Power and Energy





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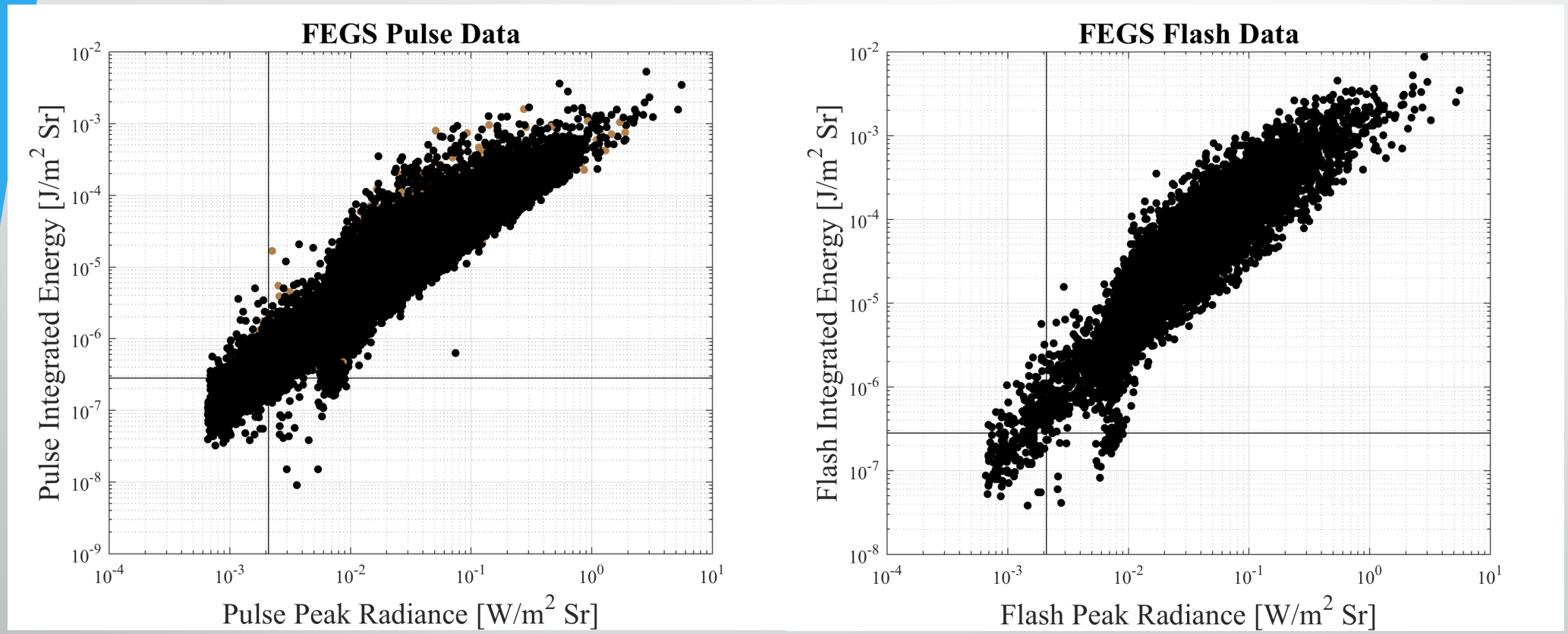
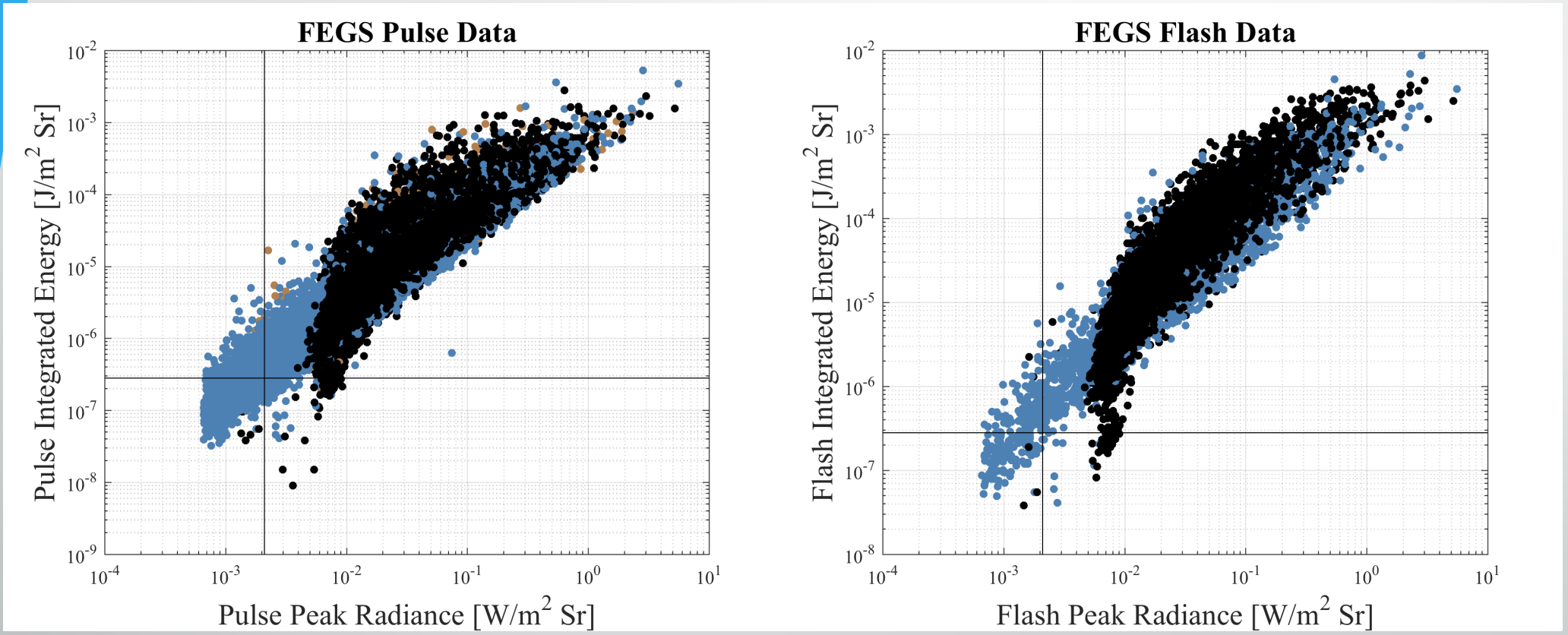
Power and Energy Distributions



Power and Energy Distributions



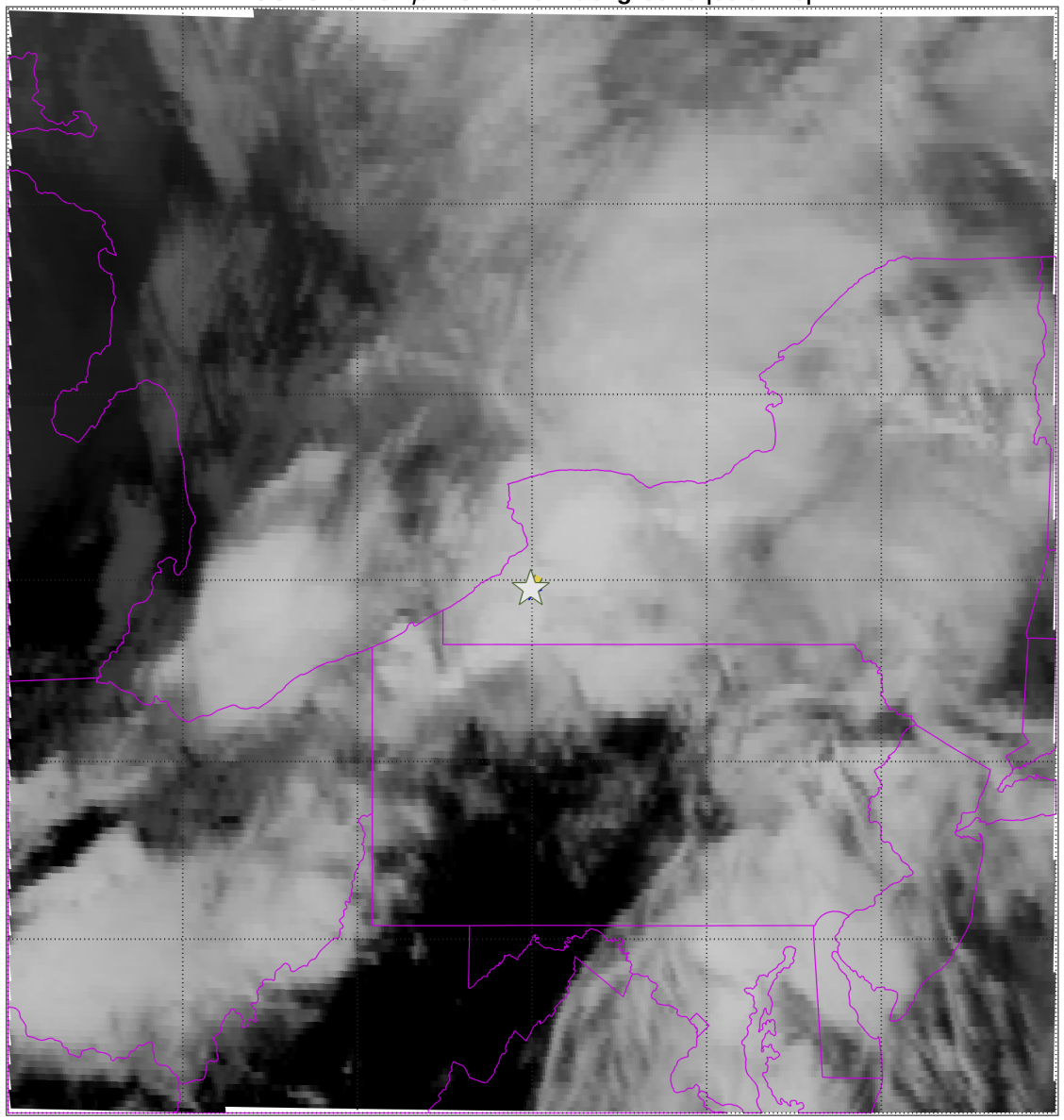
NIGHT flight **DAY flight**

Validation Intercomparison

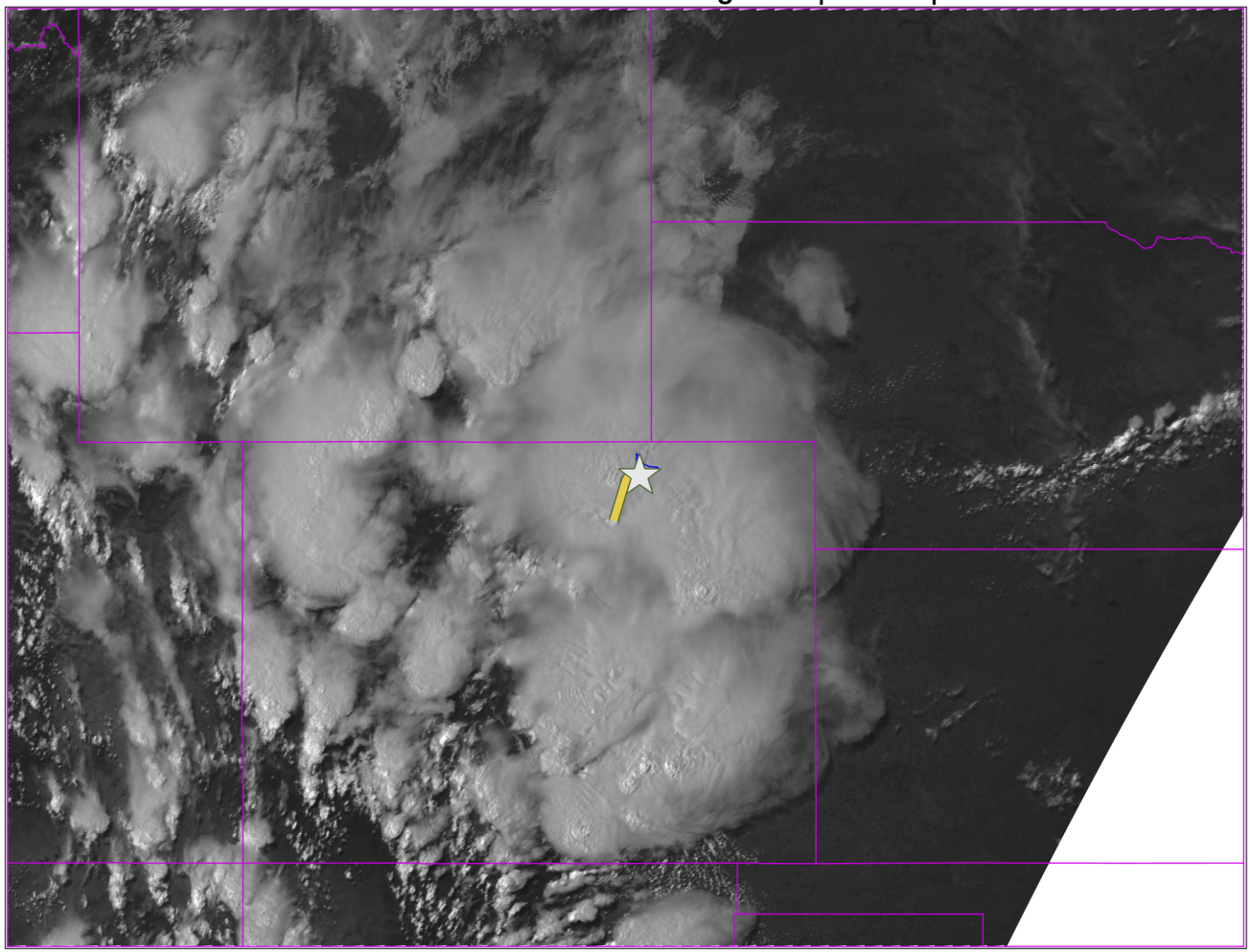
- GLM Data: LM L1b -> Mach L2

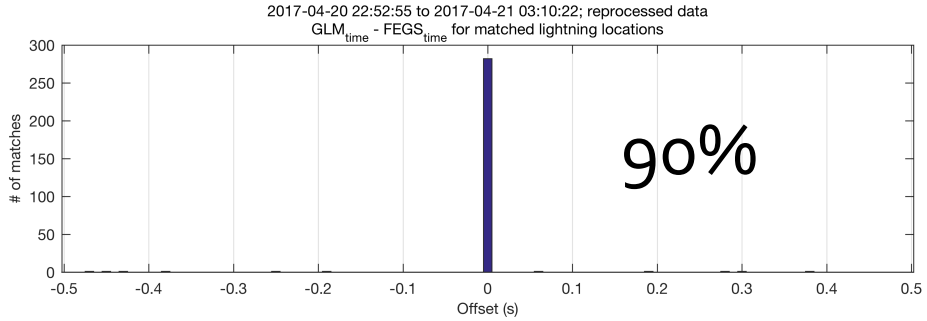
- 2017/04/20 Toronto 324 Flashes Night
- 2017/05/08 Colorado 1195 Flashes Dusk

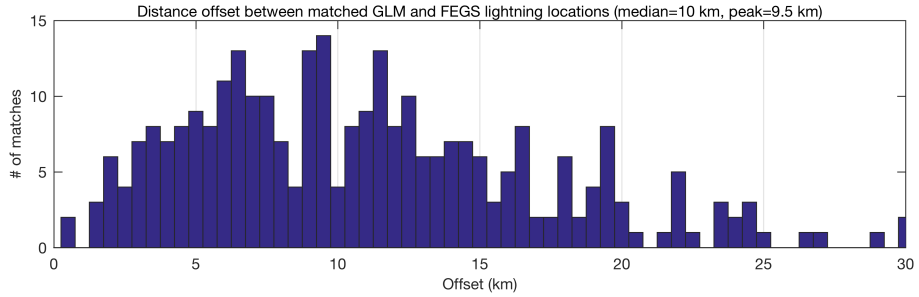
FEGS FlightMap 2017/04/21 00:29:59 - 00:30:59
GOES-13 10.7μm Channel Background |00:37:23|

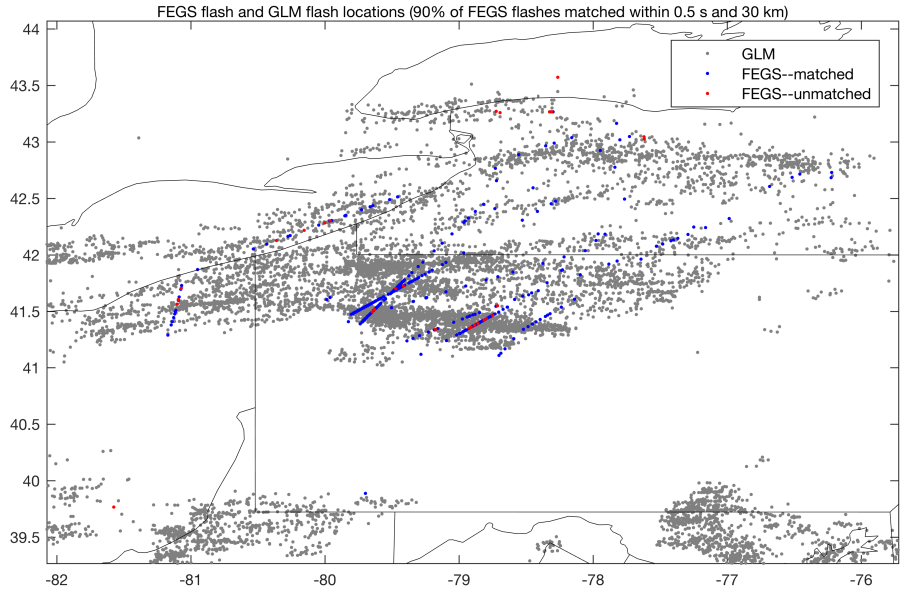


FEGS FlightMap 2017/05/08 22:59:59 - 23:04:59
GOES-15 630nm Channel Background |22:45:19|

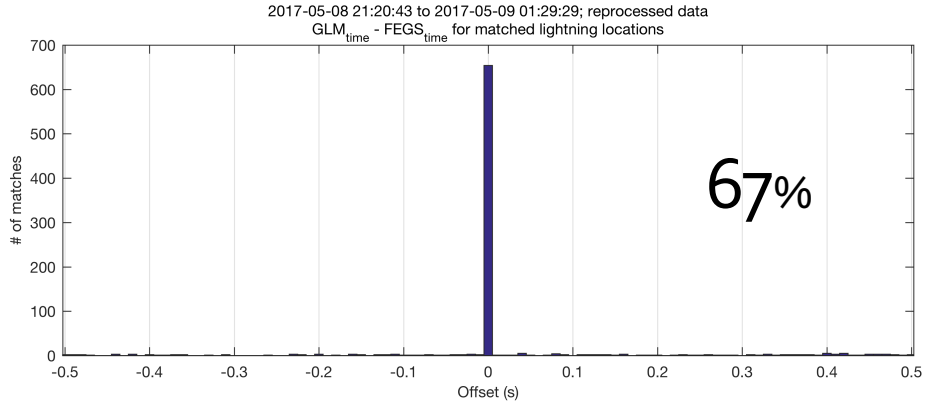


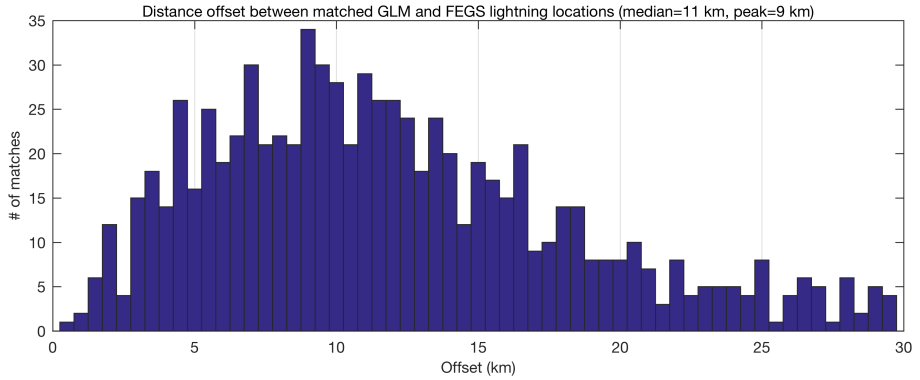

2017-04-20 22:52:55 to 2017-04-21 03:10:22; reprocessed data
GLM$_{time}$ - FEGS$_{time}$ for matched lightning locations
90%
# of matches
Offset (s)

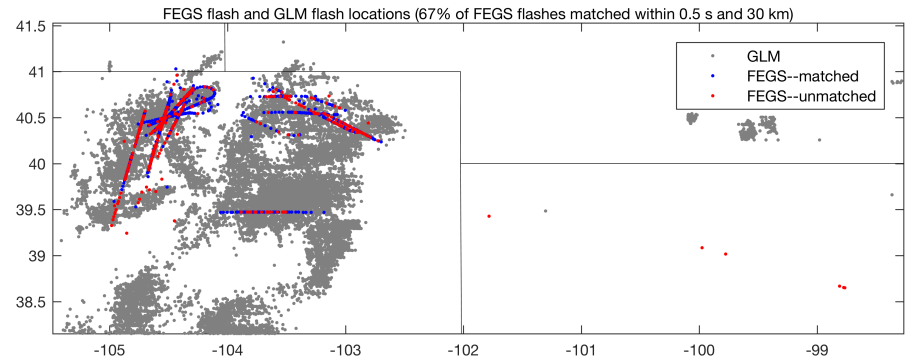

Distance offset between matched GLM and FEGS lightning locations (median=10 km, peak=9.5 km)
# of matches
Offset (km)


FEGS flash and GLM flash locations (90% of FEGS flashes matched within 0.5 s and 30 km)
GLM
FEGS--matched
FEGS--unmatched

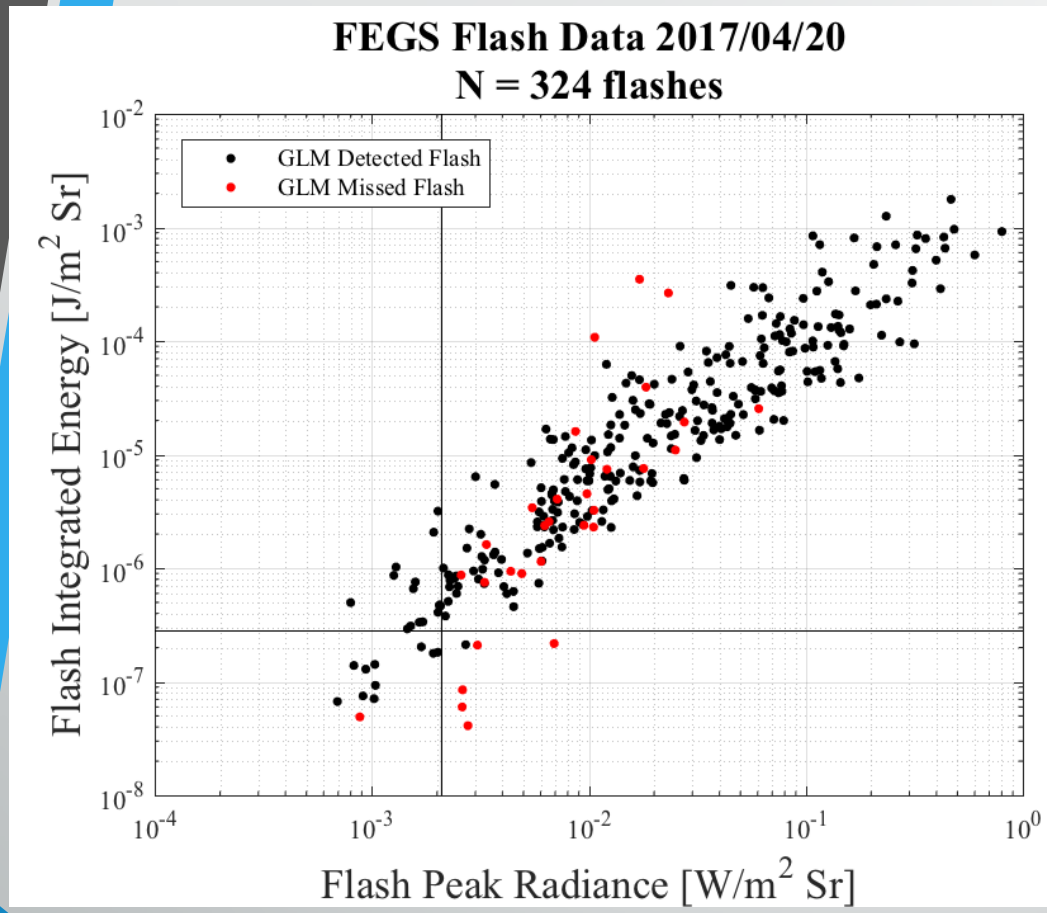
night

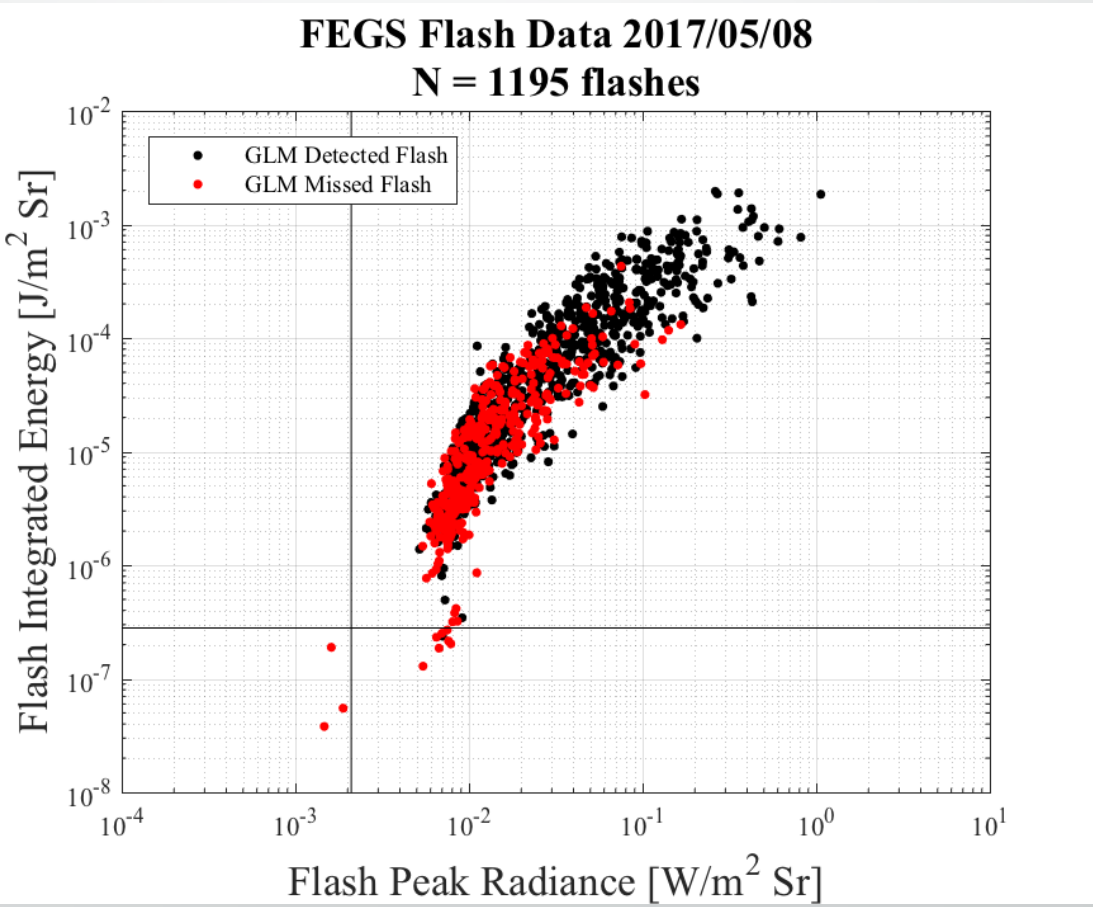

2017-05-08 21:20:43 to 2017-05-09 01:29:29; reprocessed data
GLM$_{time}$ - FEGS$_{time}$ for matched lightning locations
67%
# of matches
Offset (s)


Distance offset between matched GLM and FEGS lightning locations (median=11 km, peak=9 km)
# of matches
Offset (km)


FEGS flash and GLM flash locations (67% of FEGS flashes matched within 0.5 s and 30 km)
GLM
FEGS--matched
FEGS--unmatched

dusk

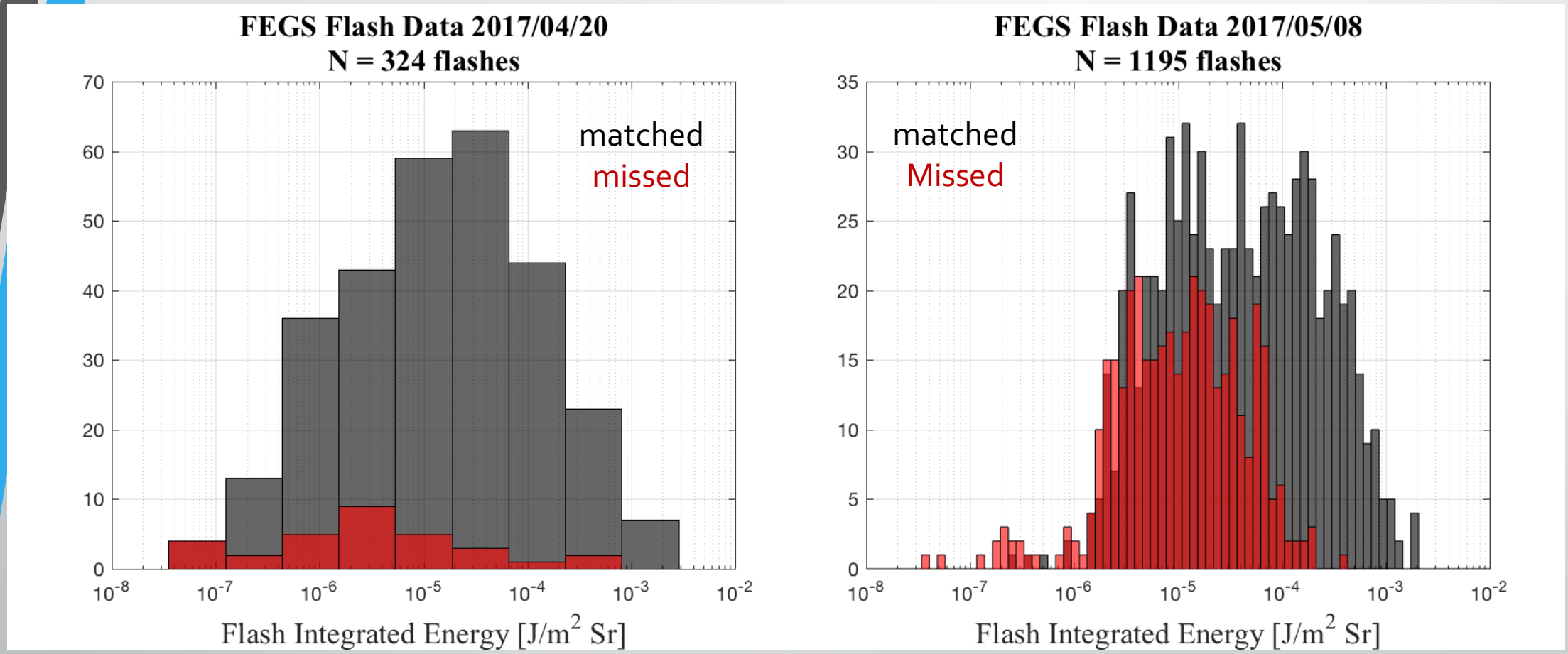

FEGS Flash Data 2017/04/20
N = 324 flashes
GLM Detected Flash
GLM Missed Flash
Flash Integrated Energy [J/m^2 Sr]
Flash Peak Radiance [W/m^2 Sr]


FEGS Flash Data 2017/05/08
N = 1195 flashes
GLM Detected Flash
GLM Missed Flash
Flash Integrated Energy [J/m^2 Sr]
Flash Peak Radiance [W/m^2 Sr]

night

dusk

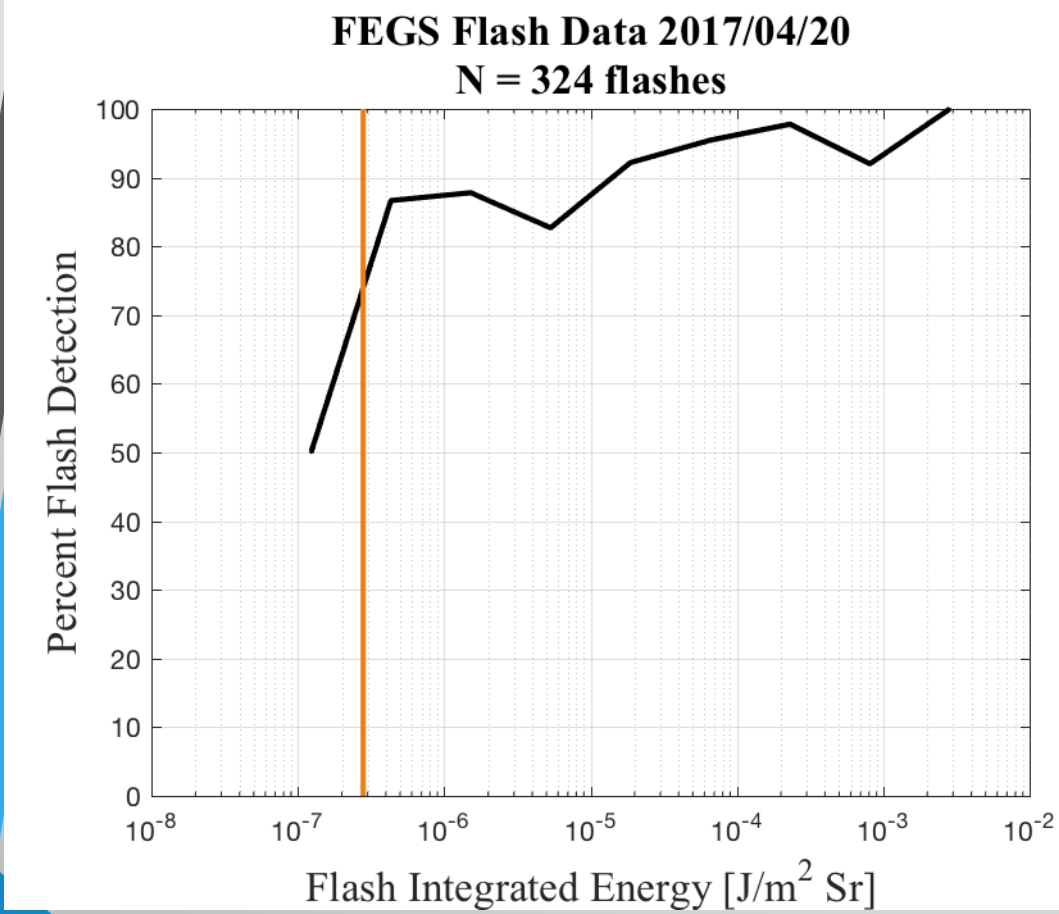
Flash Energy Distribution

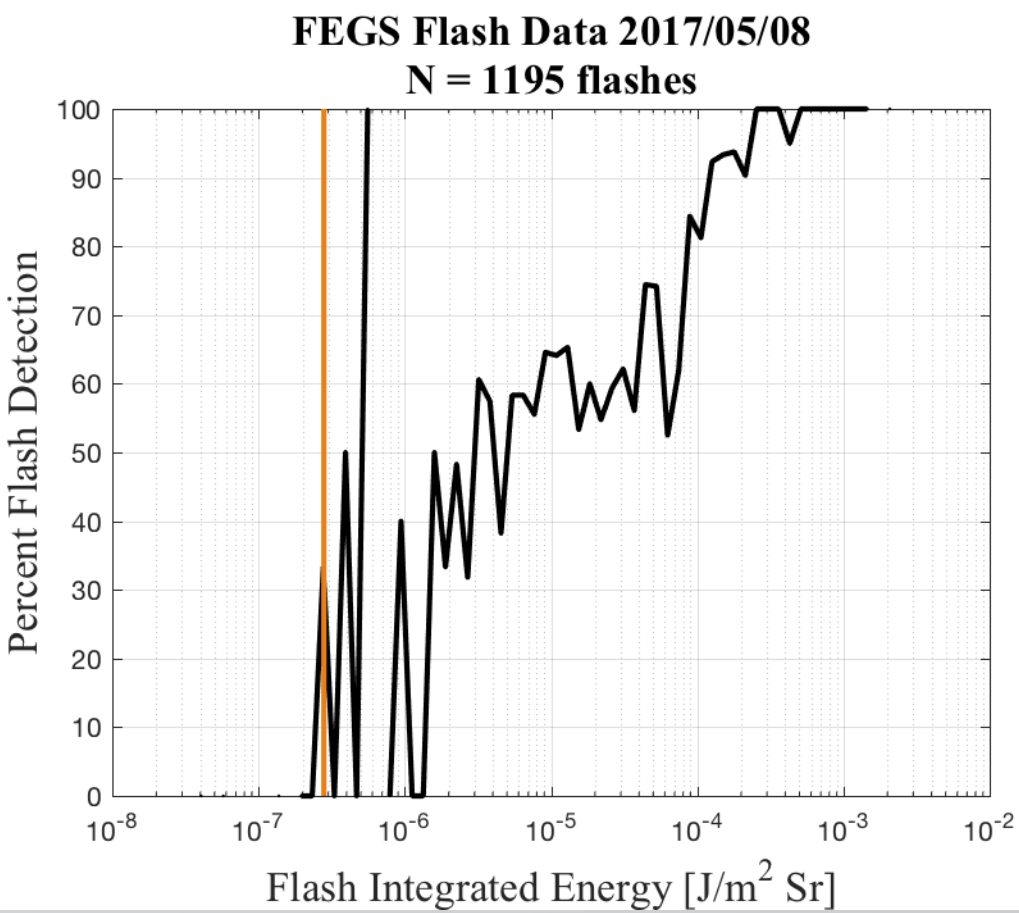


night

dusk

Percent Detection as Function of Flash Energy





night

dusk

Vertical line = 0.28 uJ/m² Sr

Full Version 1 Data Set Statistics

date	DE %	Flash Count
03/21	64	1370
04/16	89	308
04/18	56	200
04/20	90	324
04/22	86	1317
04/27	84	19
04/29	96	890
05/08	67	1195
05/12	91	773
05/17	75	563

All Flashes: 79%

Day Flashes: 75%

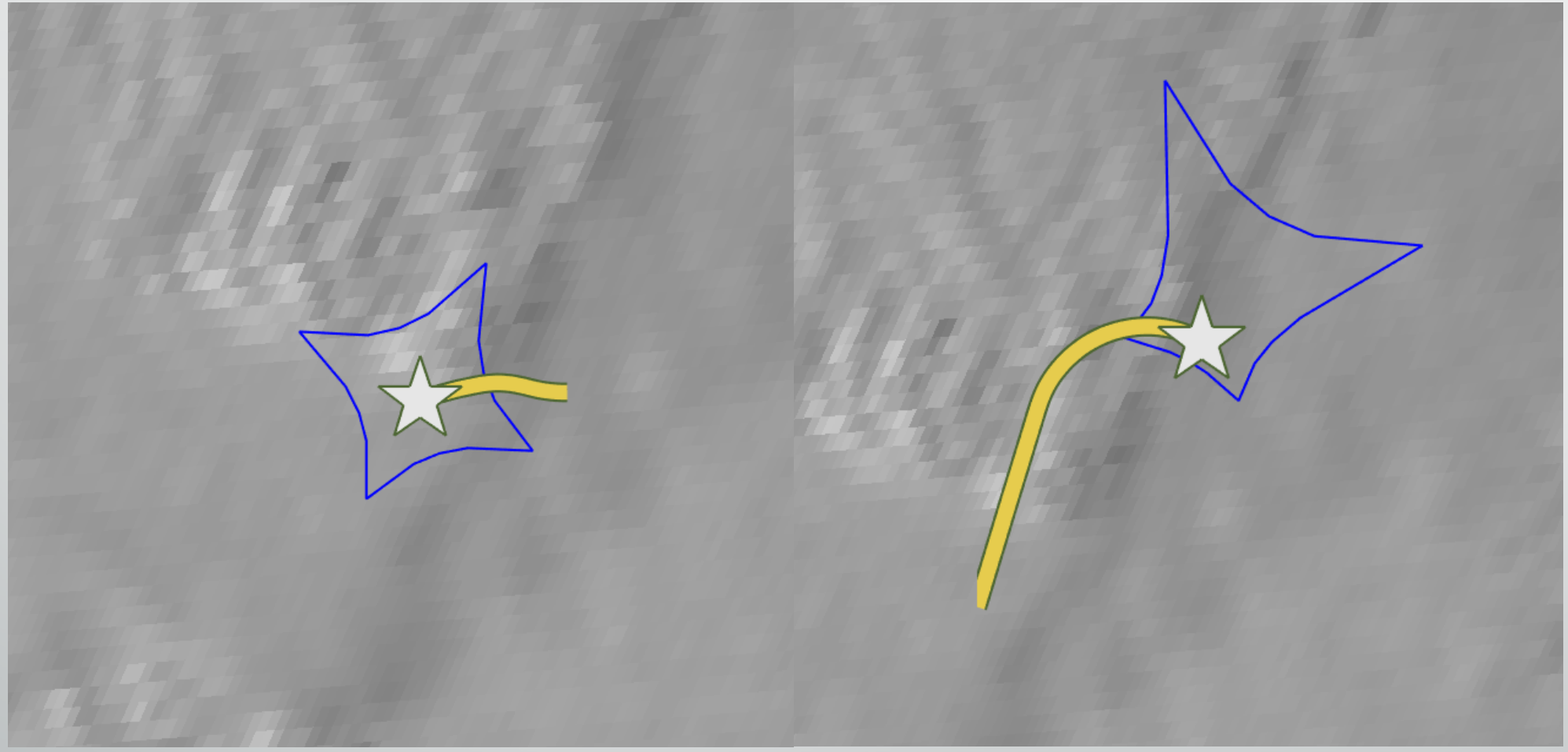
Night Flashes: 88%

Next Steps…

- Begin sub-flash and event validation
- Compare to LMAs to start shaping transfer function

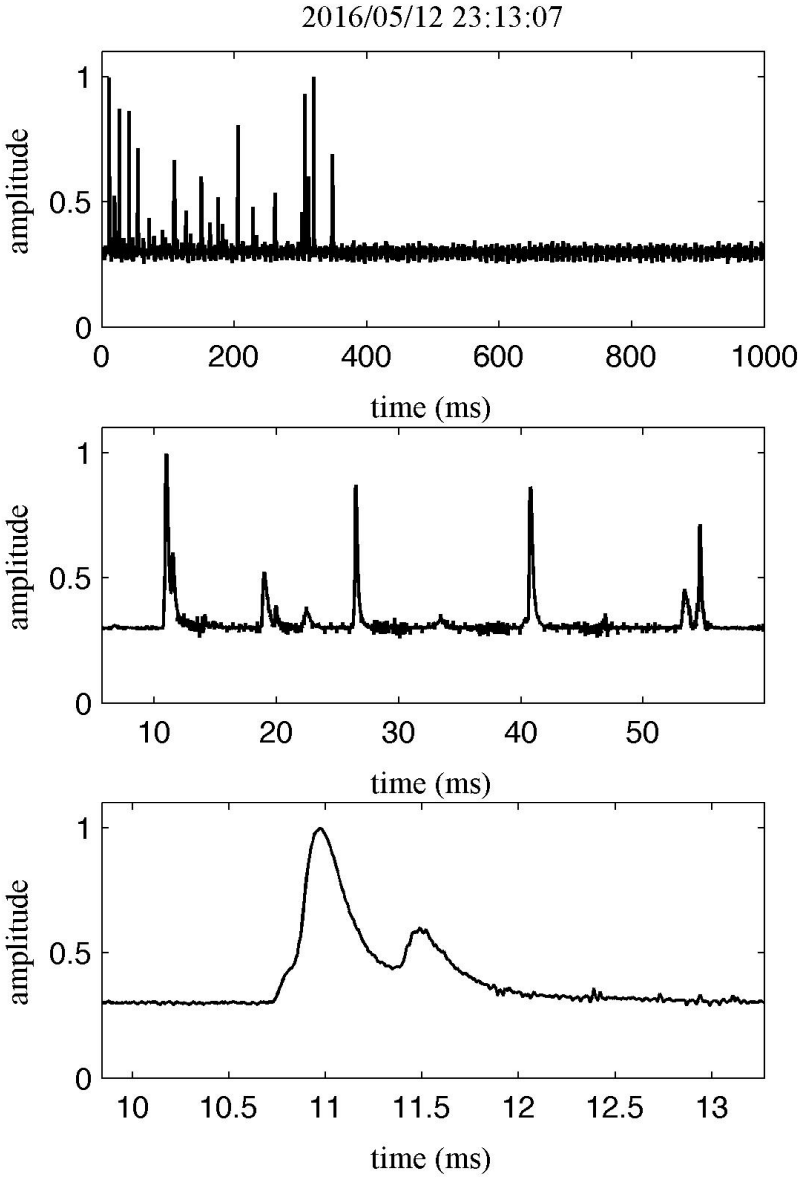
- FEGS Version 1 Pulse and Flash level on Web Portal

Questions?

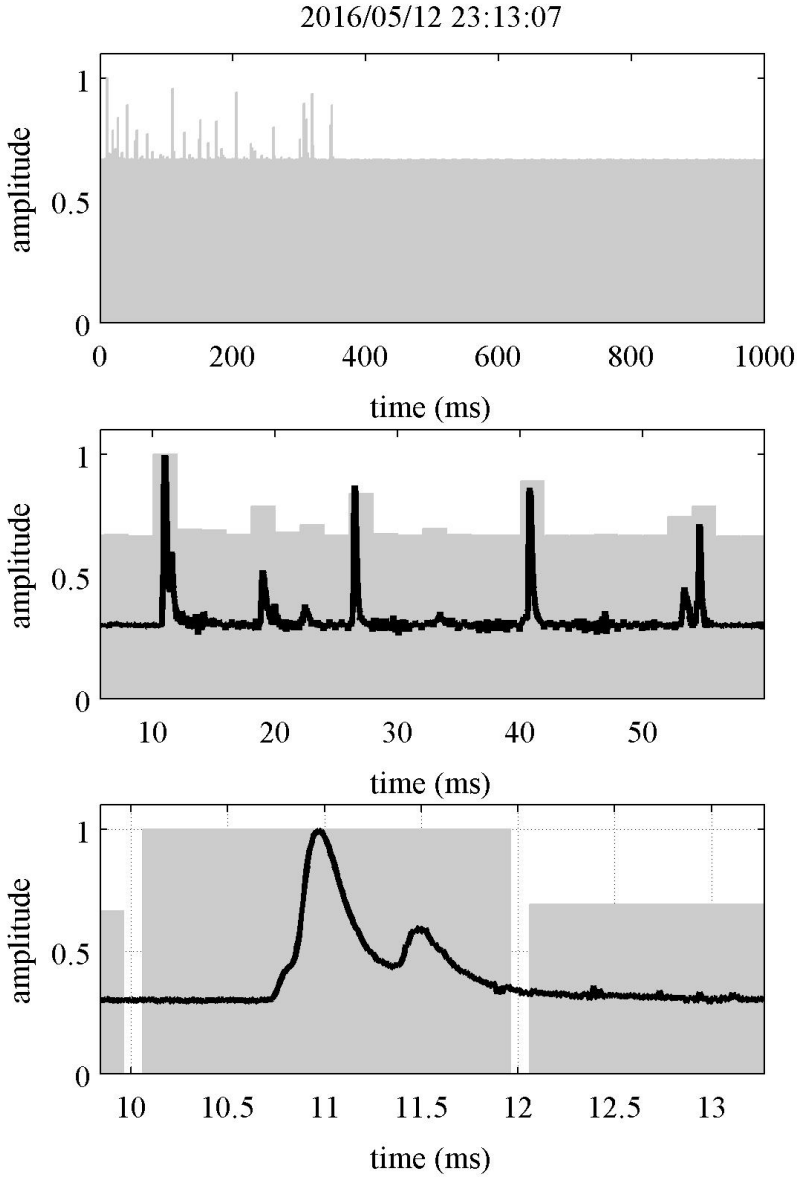


809
NASA

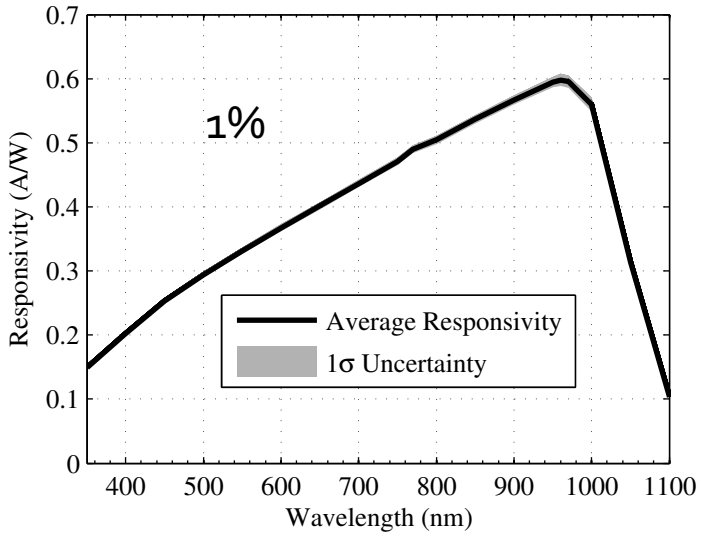
FEGS Waveforms

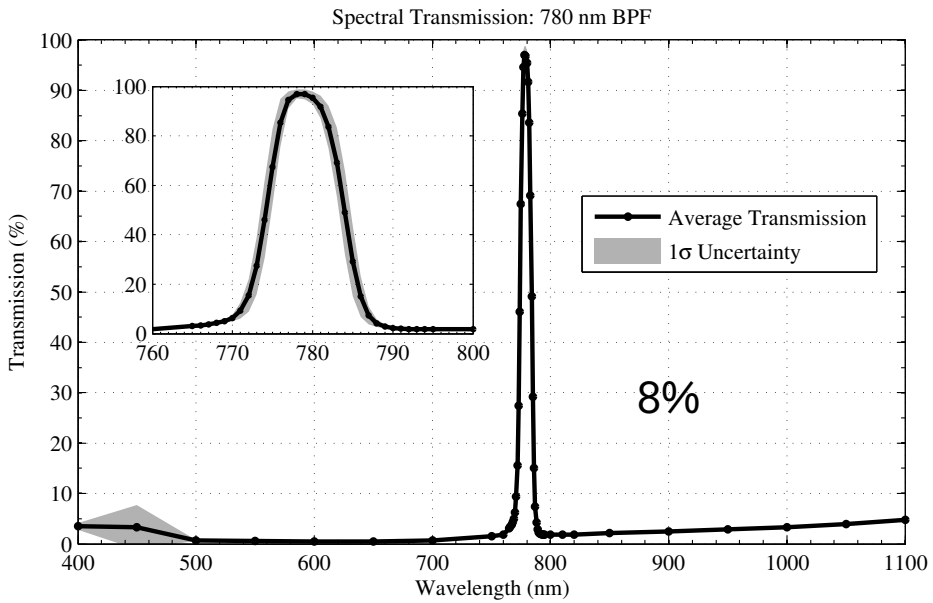


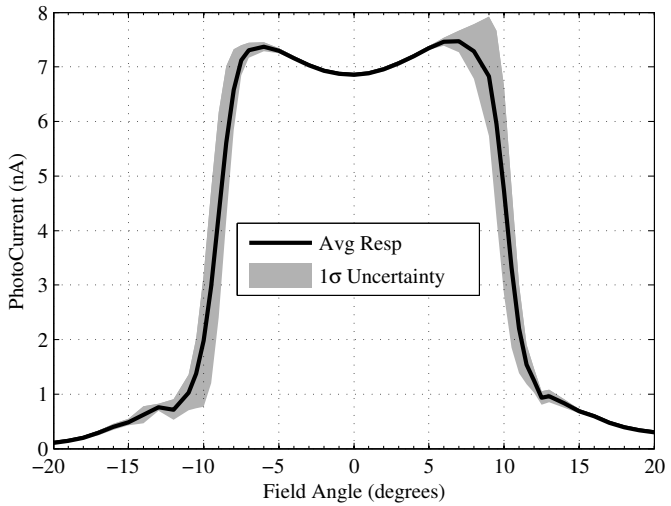
GLM Proxy Product

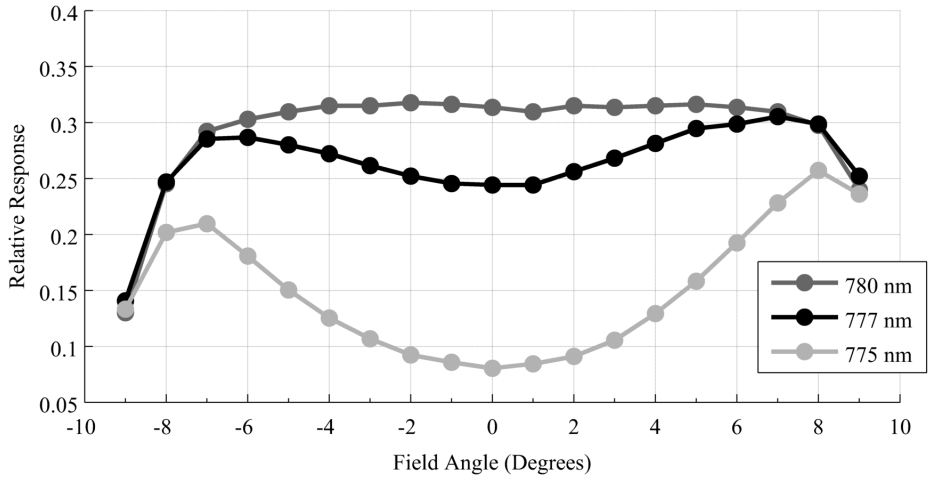


Radiometric Calibrations

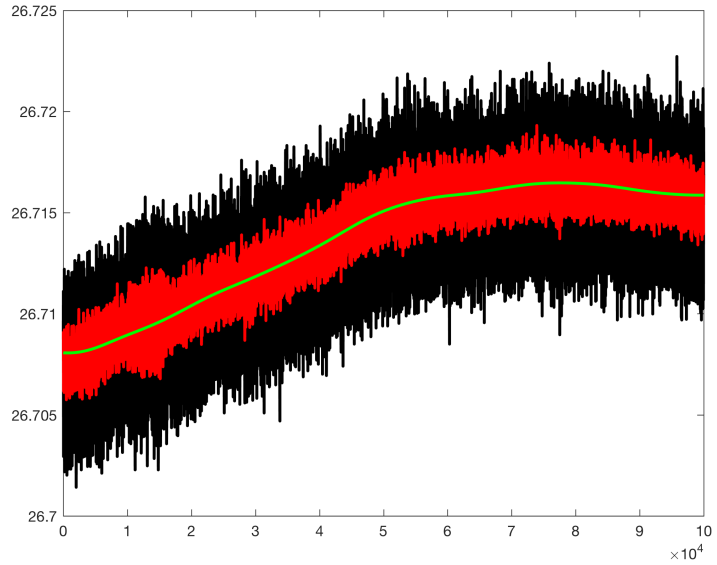


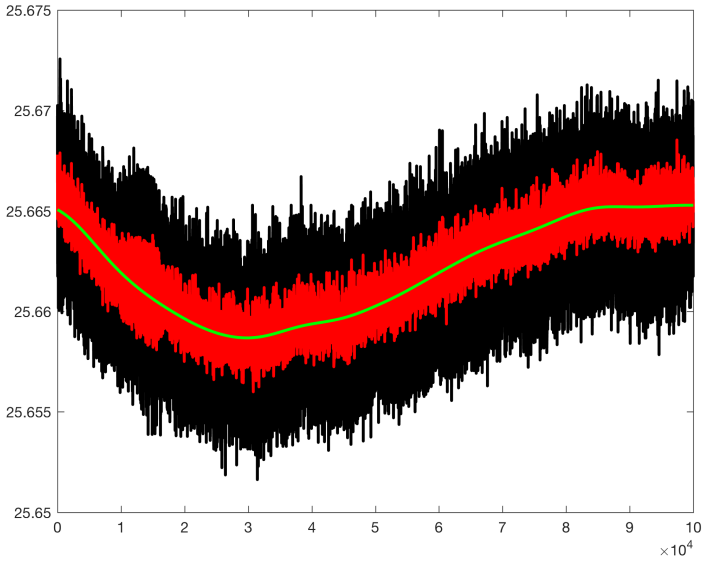


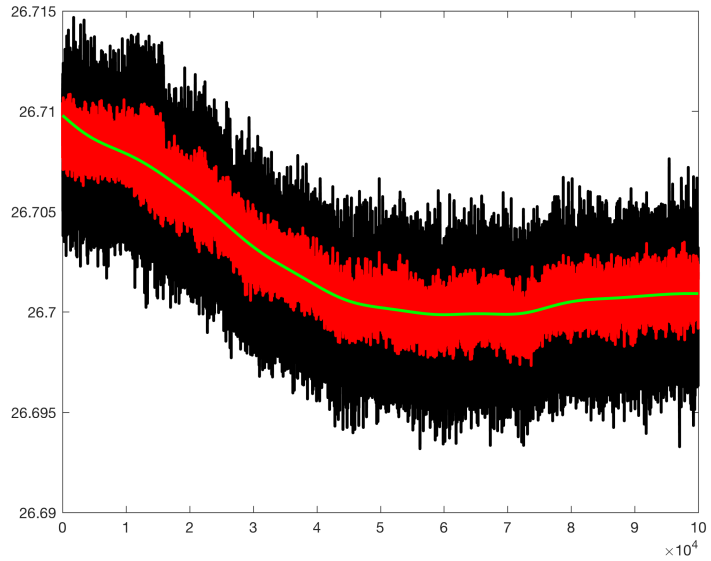


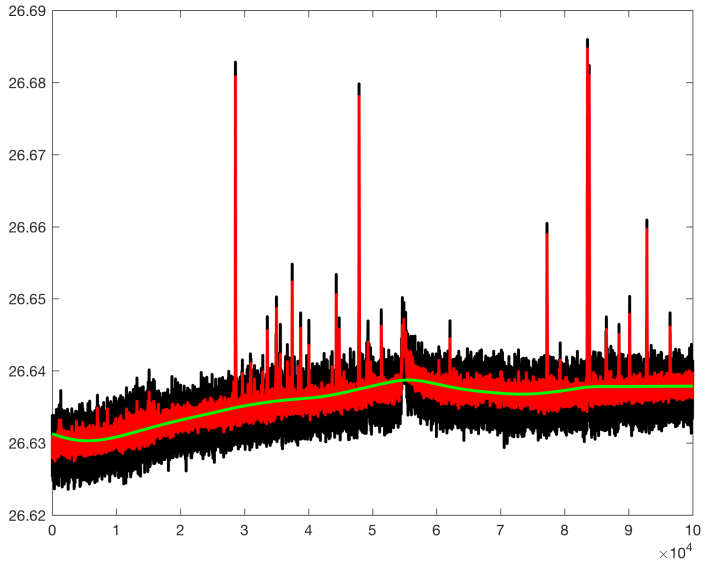
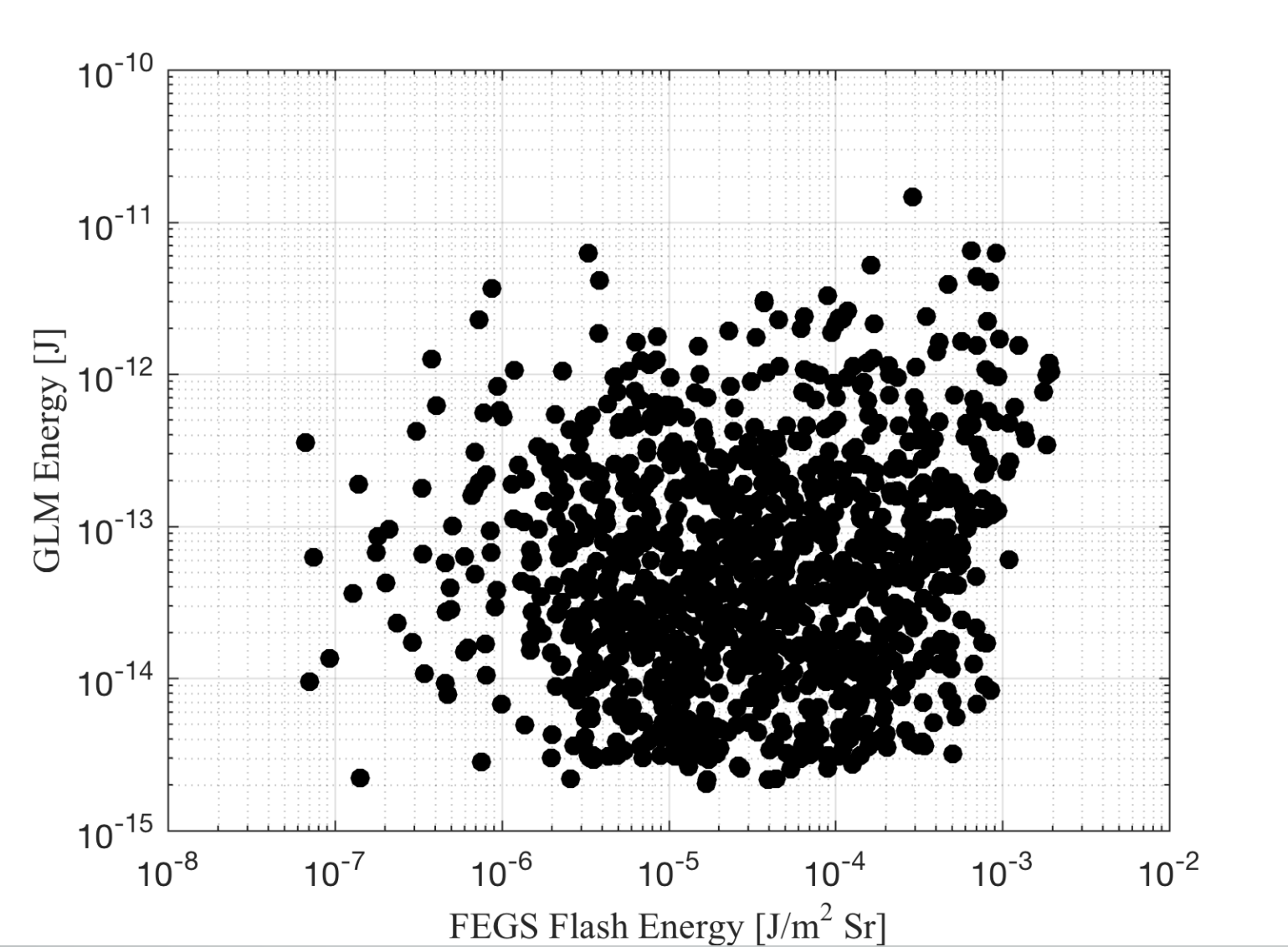


Examples of Background Variation









Radiant Energy Comparison