

Double TGFs and optical pulses observed by ASIM

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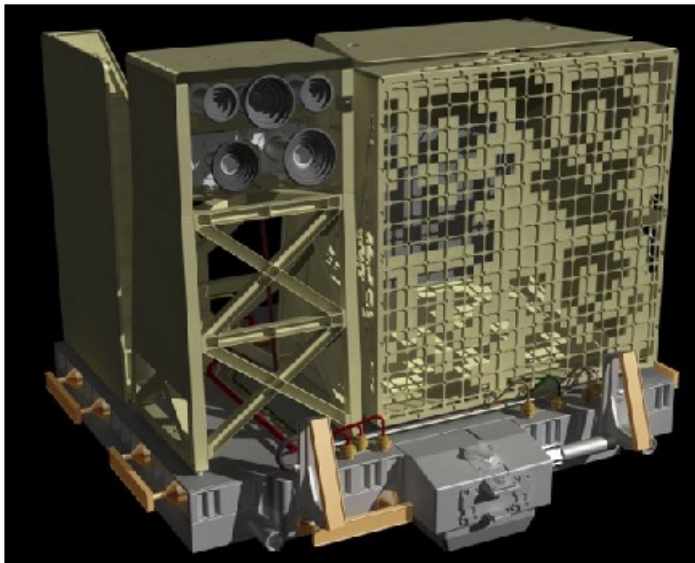
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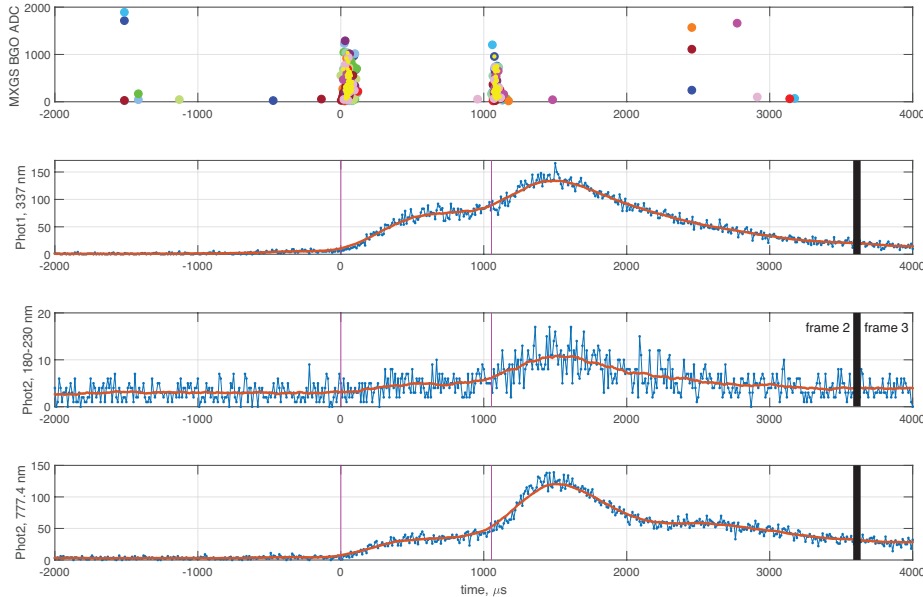
MXGS: HED and LED: 50 keV to >30 MeV

MMIA:

3 Photometers	2 Camera
Blue (337 nm)	Blue
UV (180-230 nm)	-
Red (777 nm)	Red

First of three events

2019-Nov-09 13:41:29.212



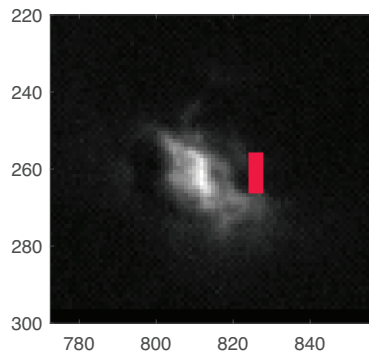
two short TGFs
($<150 \mu\text{s}$)

both high fluence and high
energies

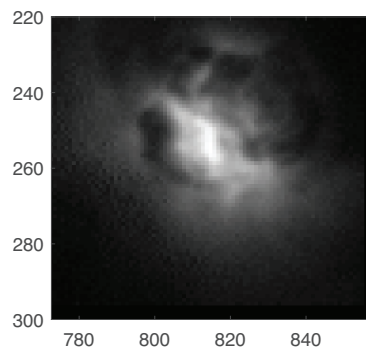
separated $\sim 1 \text{ ms}$

Each TGF is accompanied by a
bright optical pulse from a leader
- both 337 nm and 777 nm

frame 2 - 777 nm



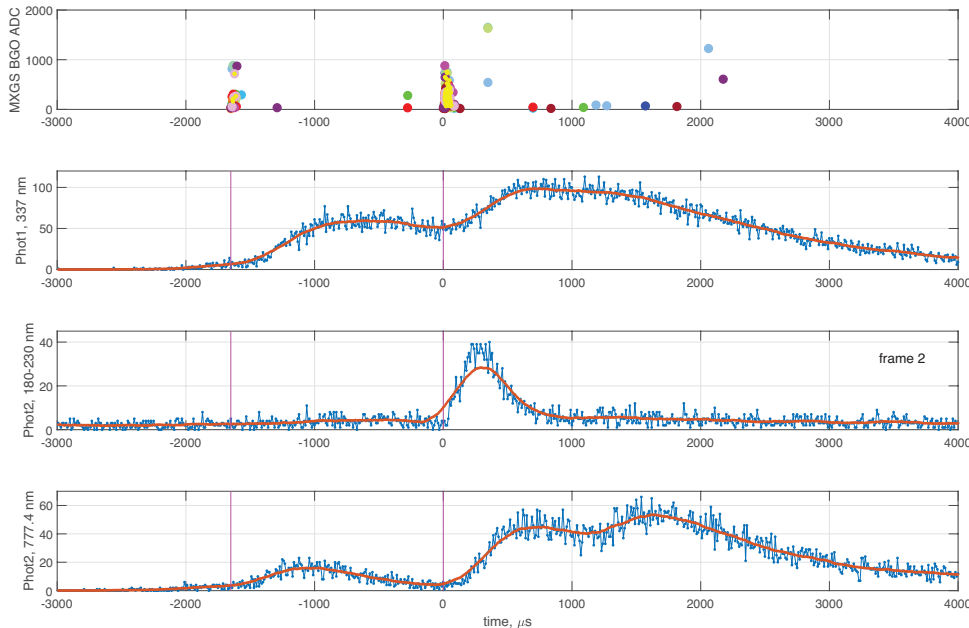
frame 2 - 337 nm



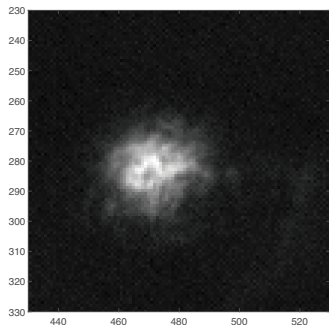
Camera images (blue and red)
indicate that they both pulses
come from the same leader
propagation
red bar: 4 km

Second of three events

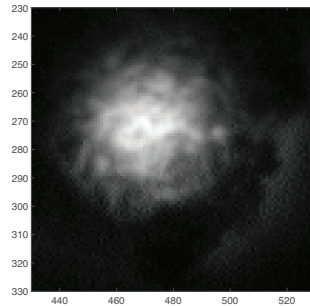
2020-Nov-10 09:16:42.621



frame 2 - 777 nm



frame 2 - 337 nm



Two short TGFs
($<150 \mu\text{s}$)

Separation: 1.6 ms

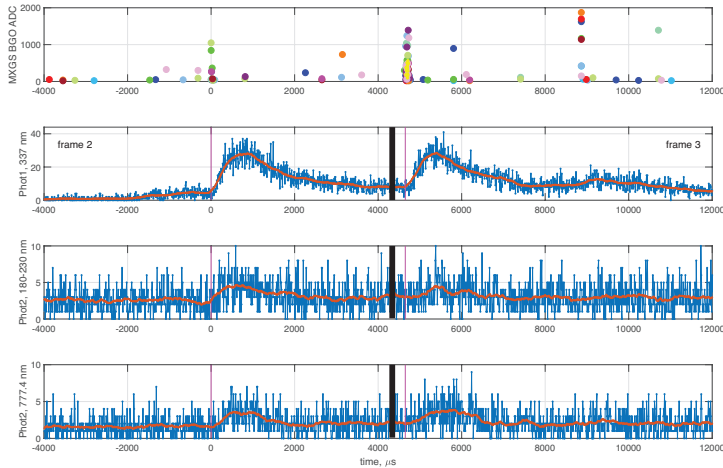
Second is a TGF with an Elve
(UV channel: 180-230 nm)
GLD: +249 kA

Both accompanied by optical
pulses - from
a leader - both 337 nm and 777
nm

Camera images indicate that
both pulses come from same
location

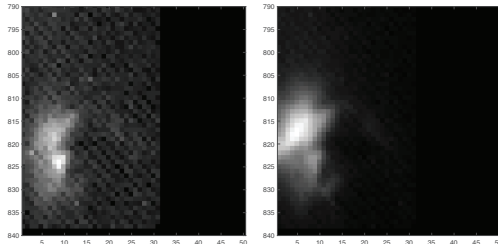
Last of three events

2021-Oct-21 14:48:50.095



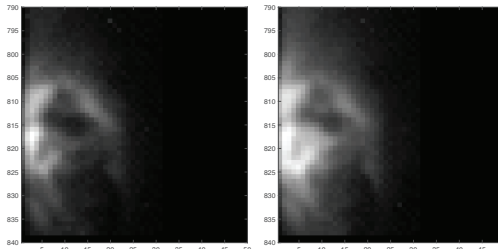
frame 2 - 777 nm

frame 3 - 777 nm



frame 2 - 337 nm

frame 3 - 337 nm



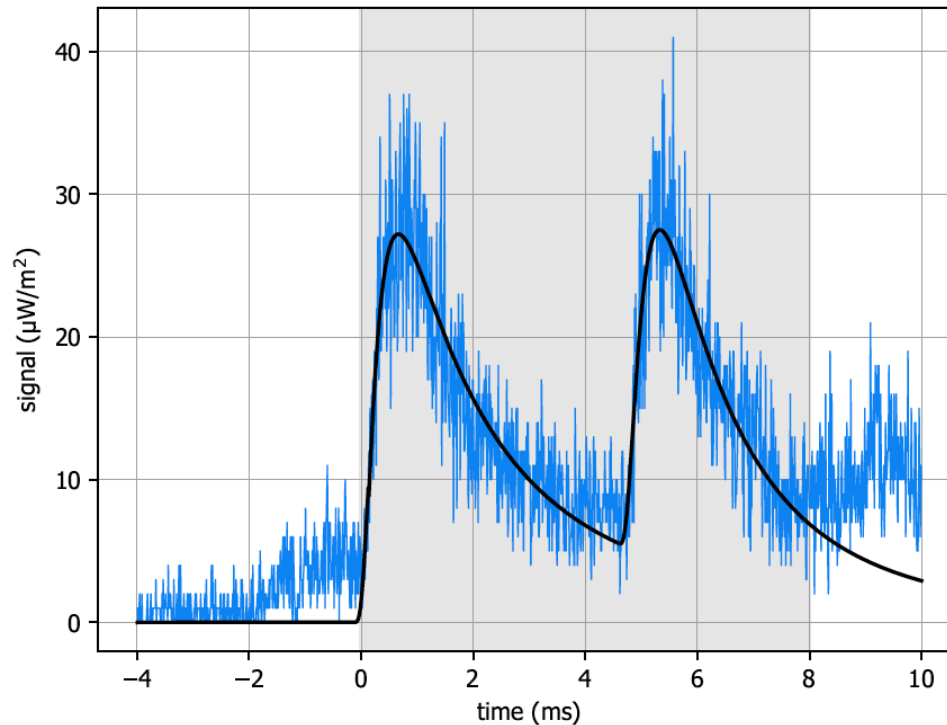
Two short TGFs (<150 μ s, one weak and one strong)

separated ~ 5 ms

At the very edge of the MMIA FOV

The two pulses are recorded in two different image-frames and indicate that they come from the same location.

Optical signals to get location below cloud top



Preliminary modeling
results

[Luque et al. 2020]

Event	1 pulse (km below cloud top)	2 pulse (km below cloud top)
191109	4.14 +/- 2.45	3.67 +/- 0.36
201110	4.27 +/- 1.10	3.94 +/- 0.46
211021	4.04 +/- 0.79	4.24 +/- 1.25

Three of a total of 15 events with double TGFs and optics:

- All three double TGFs are associated with optical pulses from a leader, due to clear signal in red channel (777 nm)
- The subsequent optical pulses come from the same location
- This suggests that both TGFs come from the leader as it propagates
- Using the shape of the optical pulses to estimate production altitude:
 - Due to uncertainties, we can only state that they come from approximately same altitude +/- 1 km