All you wanted to know about lightning but were afraid to ask

Real time : 38 msec!

6 km!

Phillip M. Bitzer, Jeff Burchfield, Daniel Walker, and the entire LASE team

ATMOSPHERIC SCIENCE

Frame 01011

What is a lightning “flash?” Are there different types of lightning?

Does lightning go up or down?

What are the different ways we can measure **light**ning?

Cloud to ground lightning starts with a ***stepped leader***

It is a hot plasma and is self propagating

It is usually branched and moves it discrete steps

It starts in the cloud, and moves toward the ground (usually...)

The brightest, and most energetic, part of lightning is the ***return stroke***

This is the part of lightning we see...

The return stroke can reach temperatures >5x the surface of the sun (30000 K)

and propagates (up) at 1/3-2/3 the speed of light

The current (and luminosity) wave propagates up the channel

Not just one leader....


3.3 km

50 milliseconds later....

(or about a tenth as fast as you can blink your eye)

(or about ten beats of a hummingbird’s wings)

As an aside, this stroke was located ~5km from the first...

7 ms total

Frame 00323


1st leader


2nd leader


13th de la cadre

1st leader

We call this a
dart leader

2nd leader

Same path!

A typical lightning ***flash**** has 3-5 return strokes and lasts for about half a second

We “see” each stroke as a flicker of light, and it lasts for a couple of milliseconds

(or about one beat of a bee’s wings)

**A “flash” is a collection of discharges that are “close” in time and space*


We call this process *continuing current*
and can last for hundreds of milliseconds
Sometimes, we get *continuing light*
from a single stroke...
Frame 00487

We call this process ***continuing current***
and can last for hundreds of milliseconds

This is the type of lightning thought
to be responsible for forest fires

We call this process ***continuing current***
and can last for hundreds of milliseconds

This is the type of lightning thought
to be responsible for forest fires

“Regular” negative CG

Frame 00083

Continuing current

Positive CG lightning

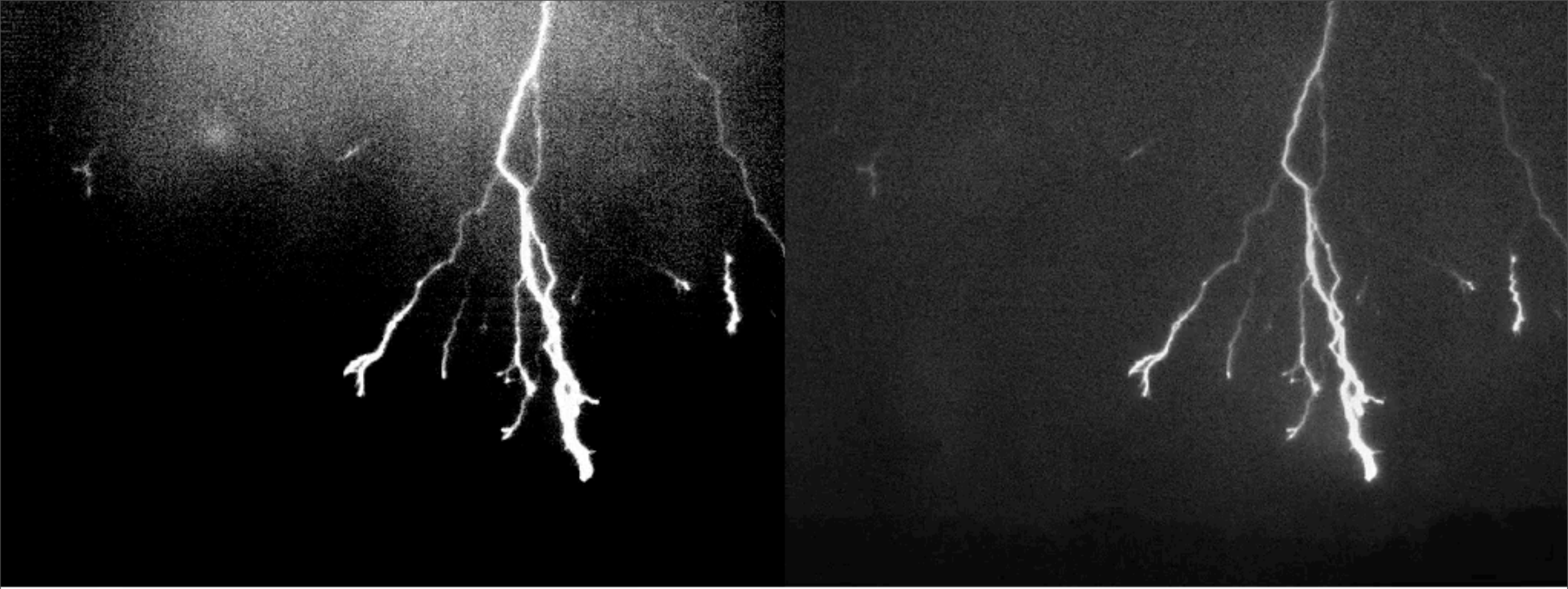
A lot more charge is neutralized by this stroke

Frame 00435

Fine - lightning is not just a “flash;”
it’s comprised of several processes...

and lightning comes in two different polarities...

but, can we measure lightning
other ways besides a camera?


Light Curve
1•10^7
8•10^6
6•10^6
4•10^6
2•10^6
0
0
100
200
300
400
500
Fr. Num
−0.100
−0.160
−0.220
0.0
0.5
1.0
1.5
Milliseconds; Reference time of origin: 80982.272500
Electric field
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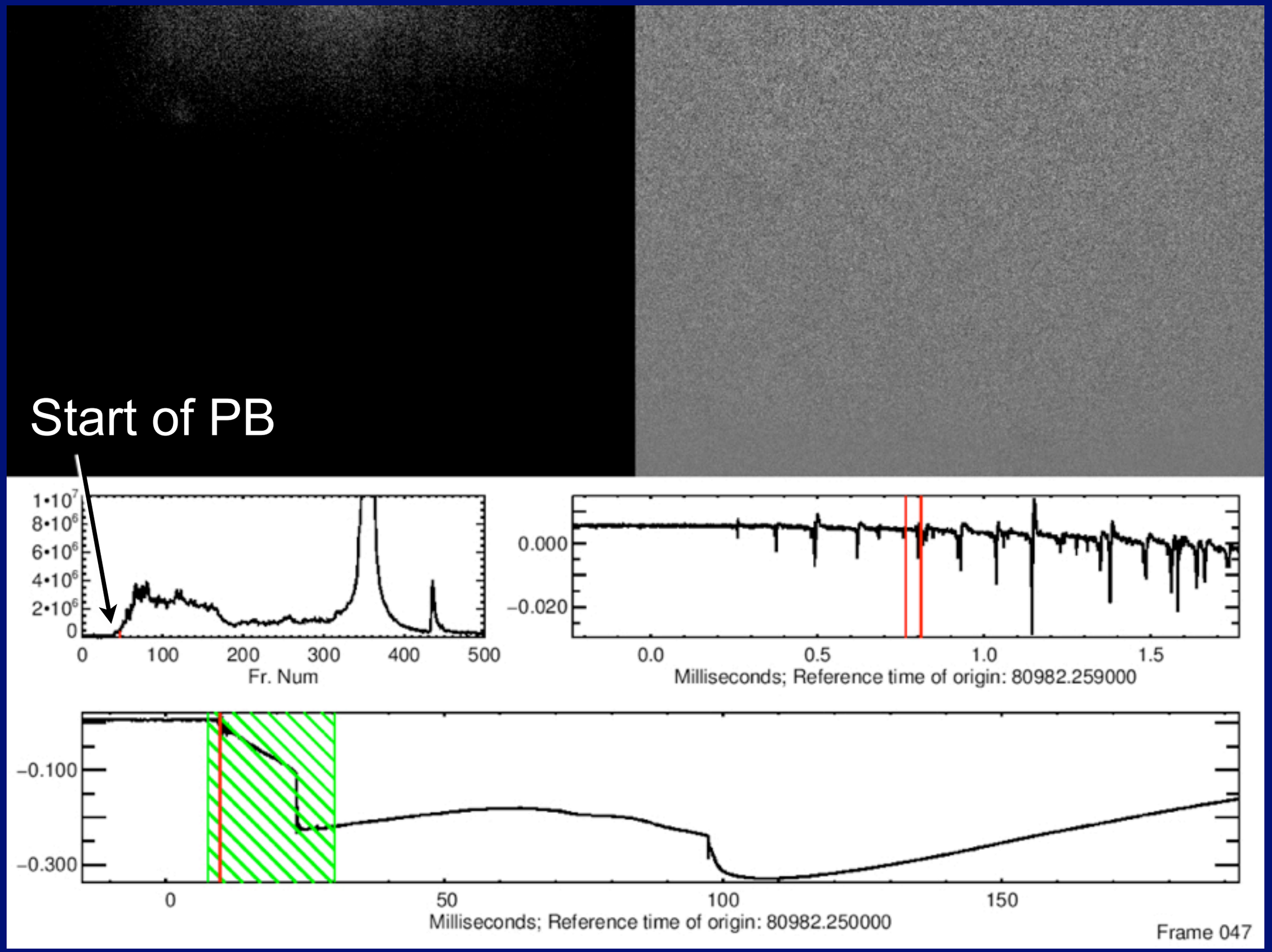
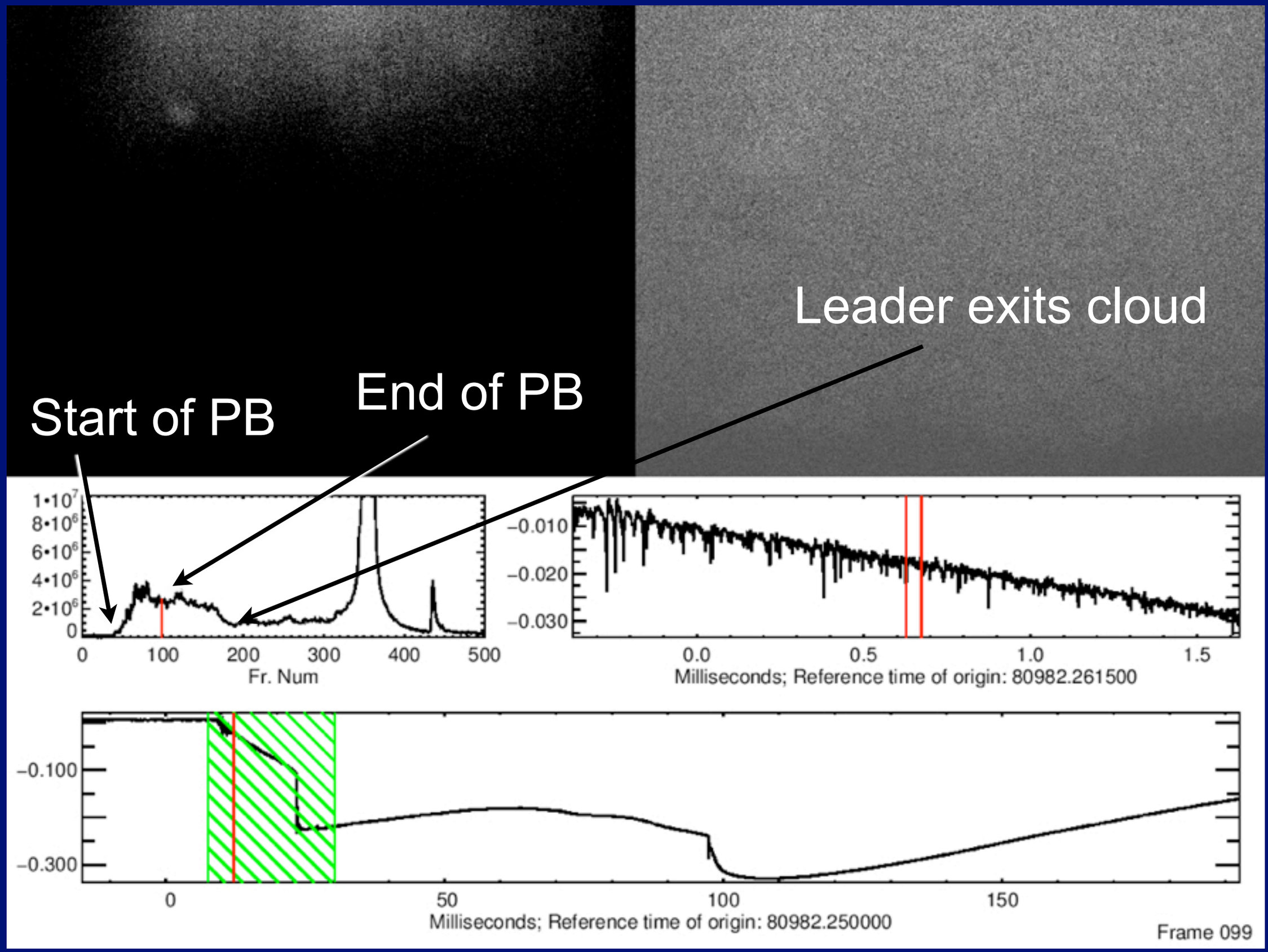
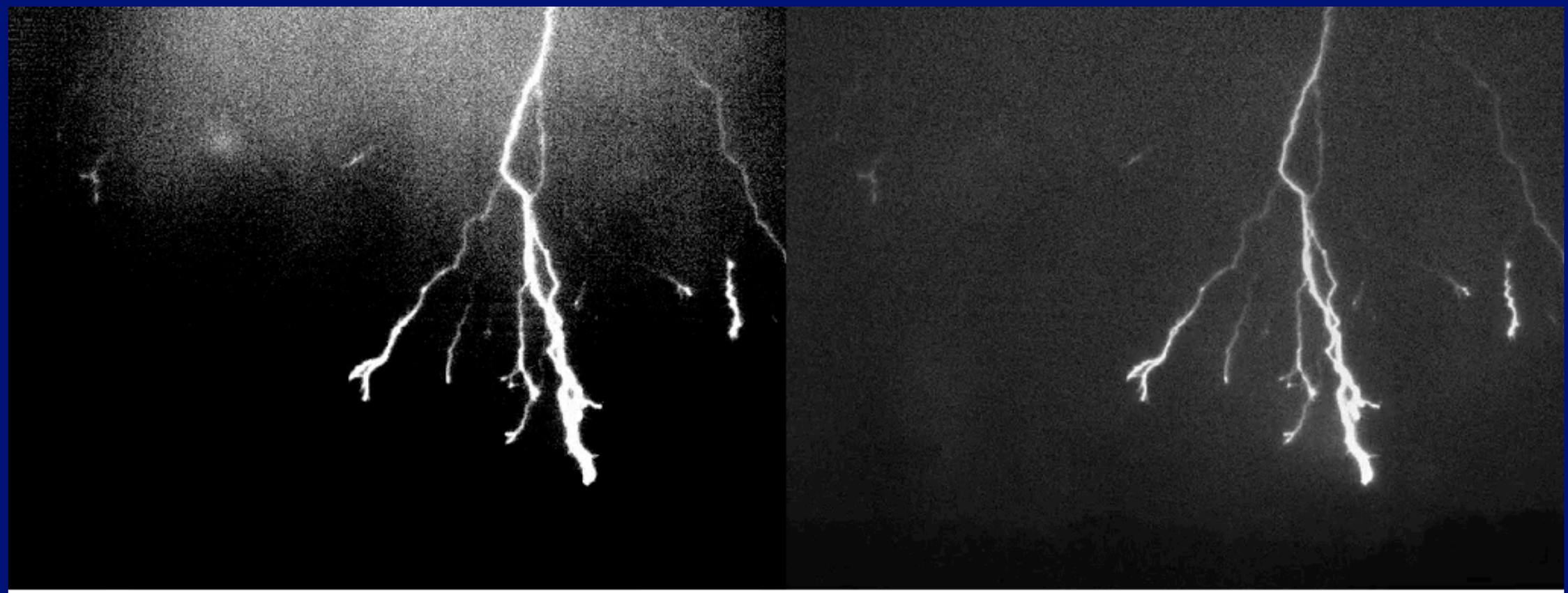
−0.300
0
50
100
150
Milliseconds; Reference time of origin: 80982.250000
Frame 344



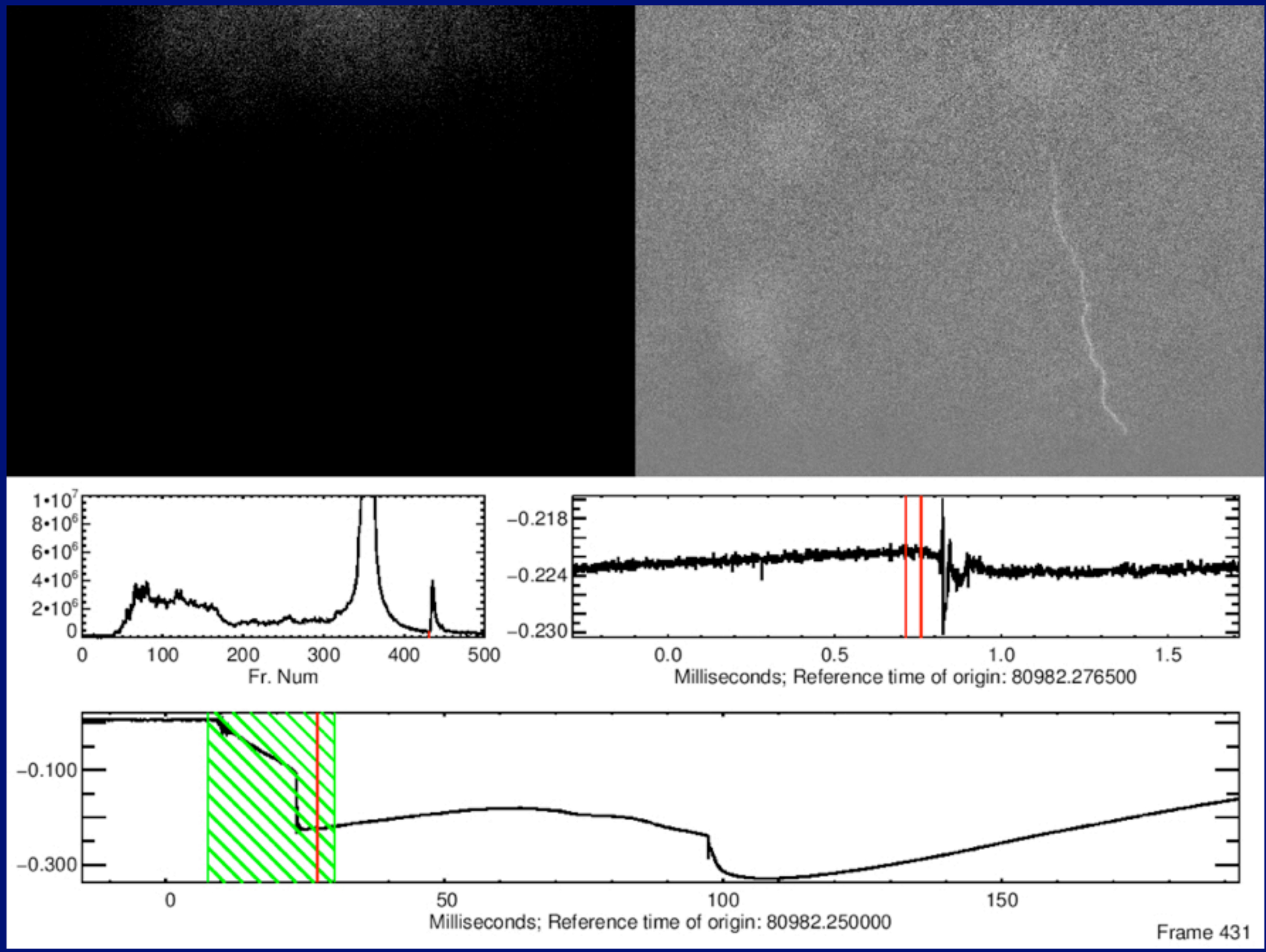
PB = Preliminary Breakdown, i.e., initiation



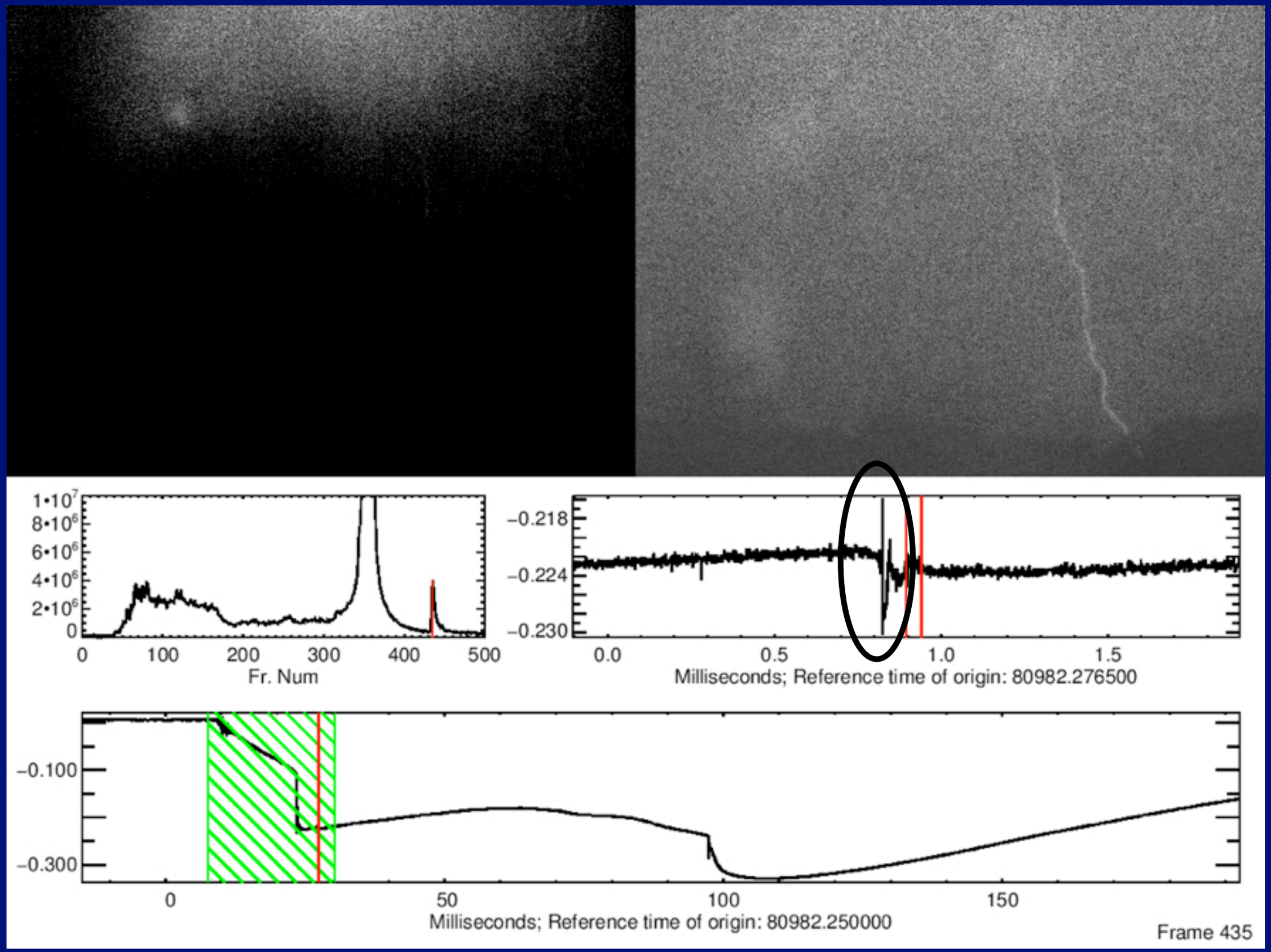
PB = Preliminary Breakdown, i.e. initiation



Right before the return stroke

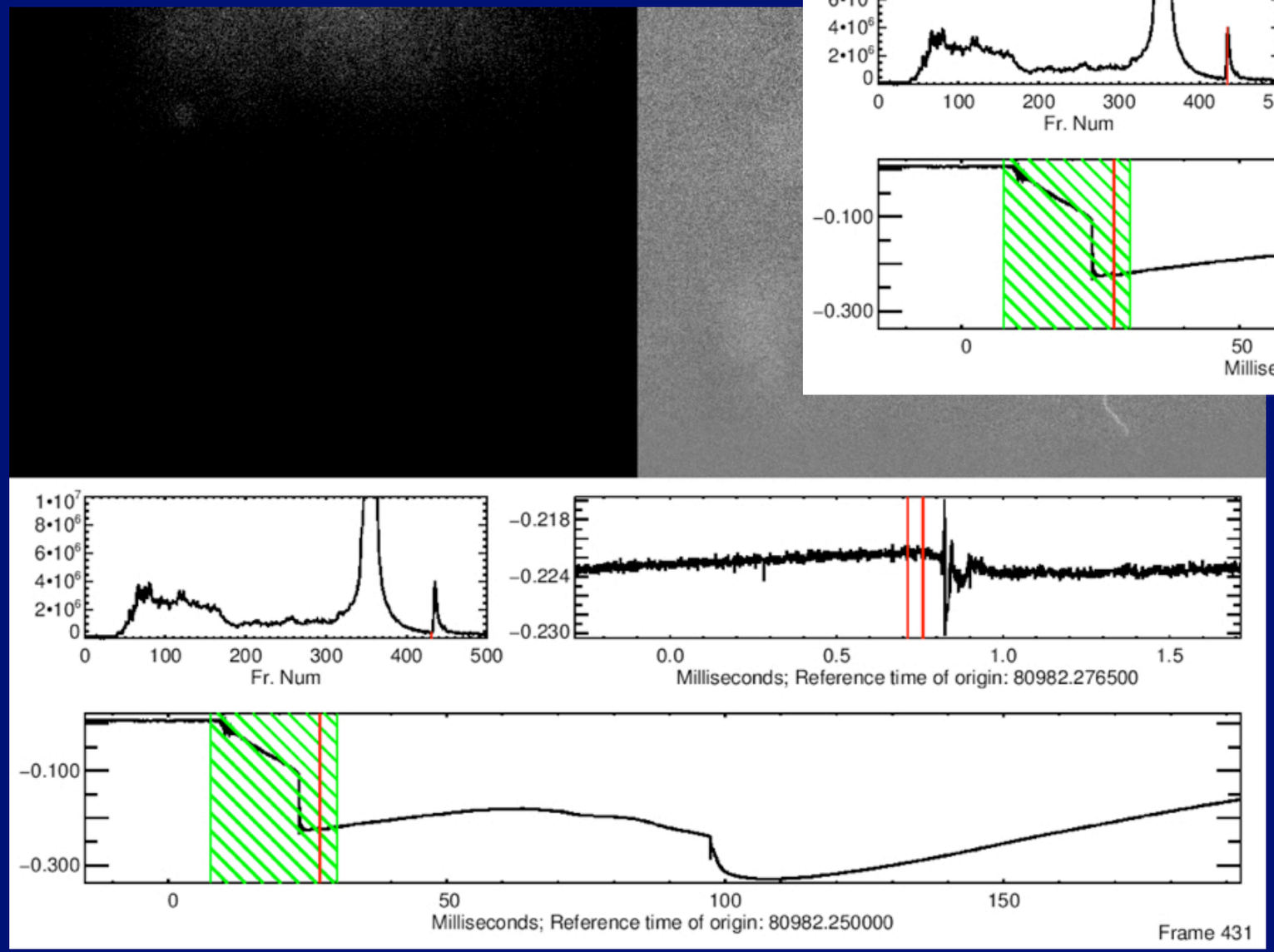


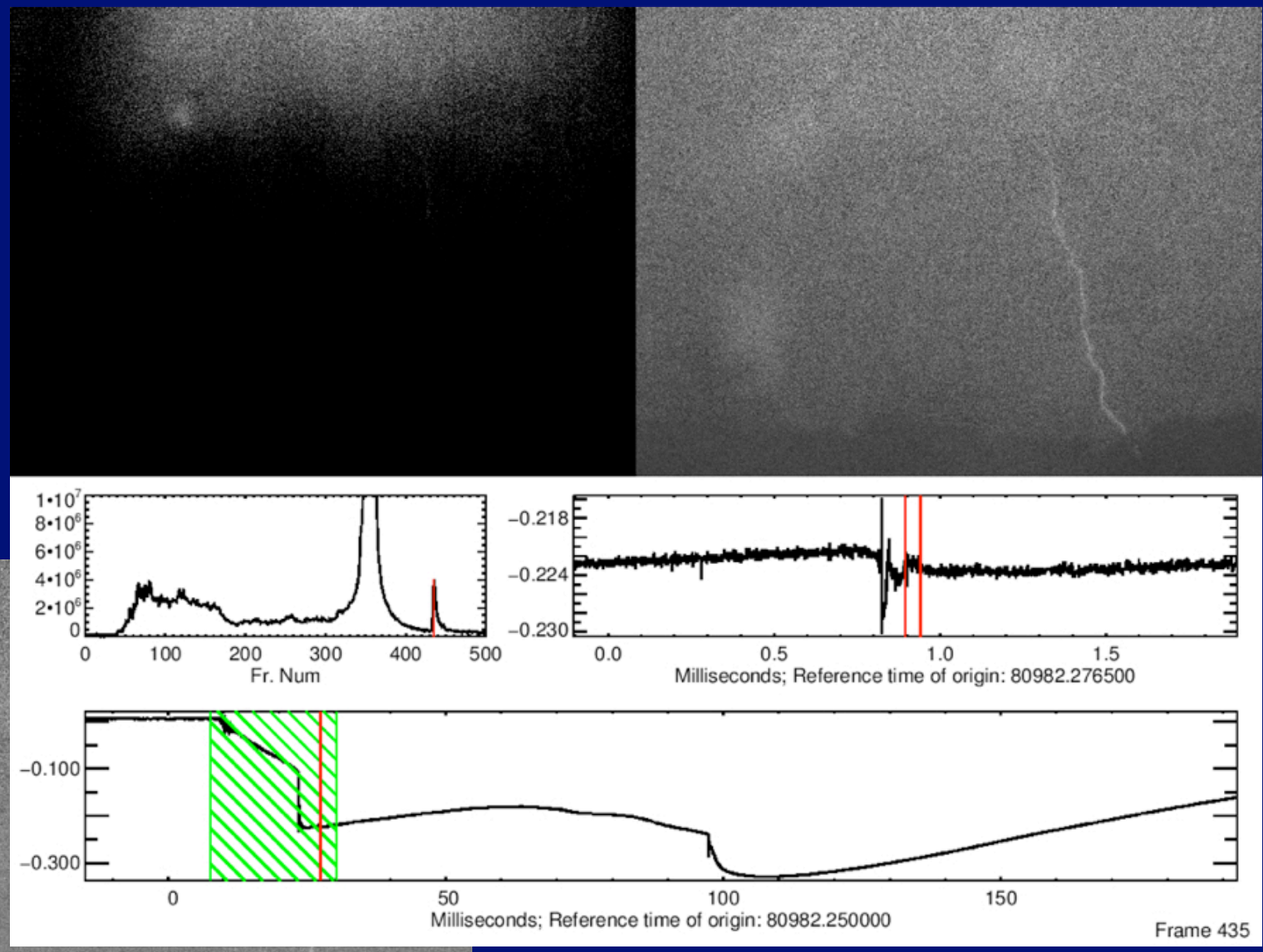
“K change” (an in cloud discharge) before



"K change" (an in cloud discharge) after

“K change” before





“K change” after

Not all lightning starts by going “down...”

Some leaders can go up!

2 km

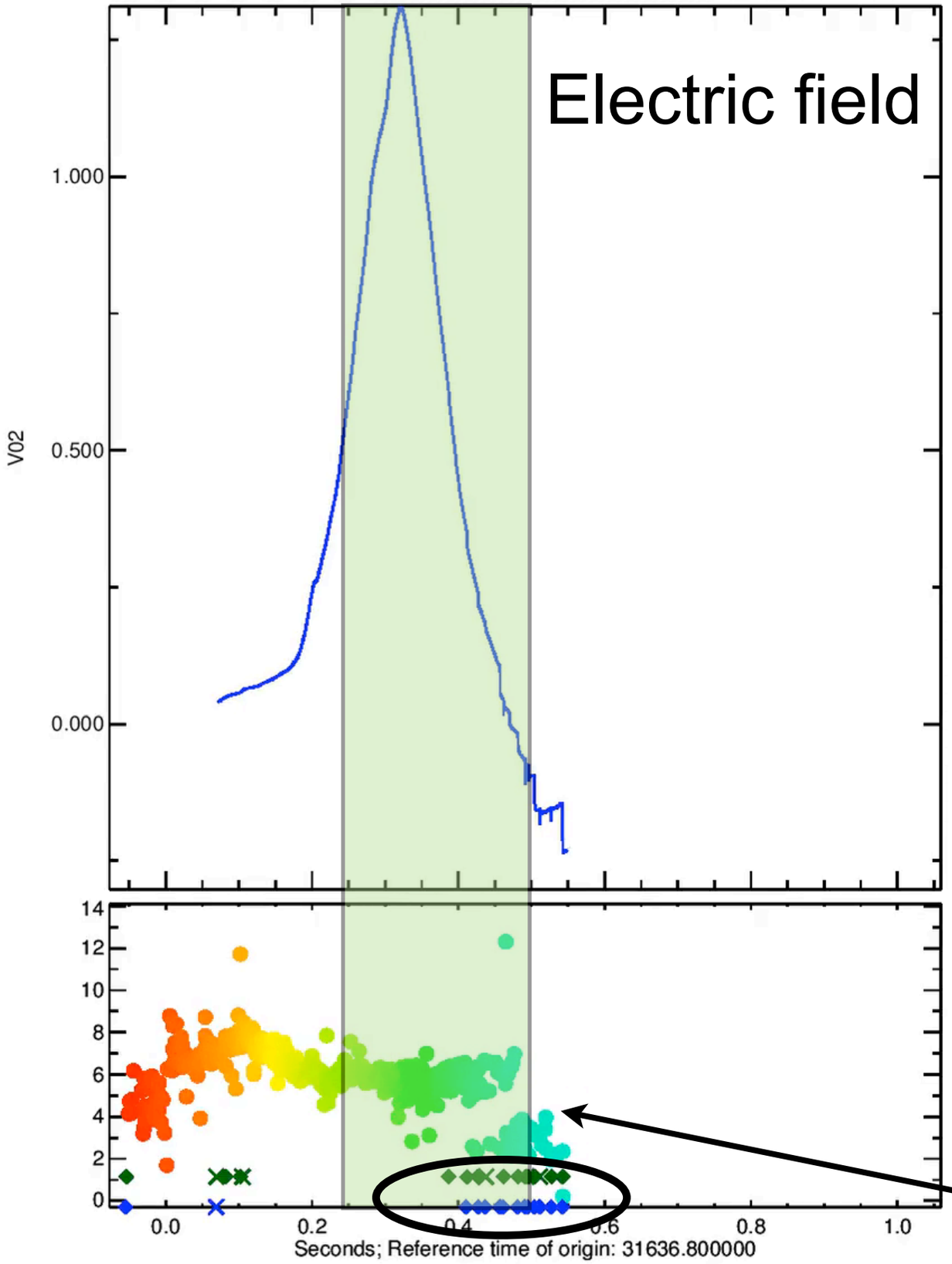
Real time : 115 msec

Frame 00823

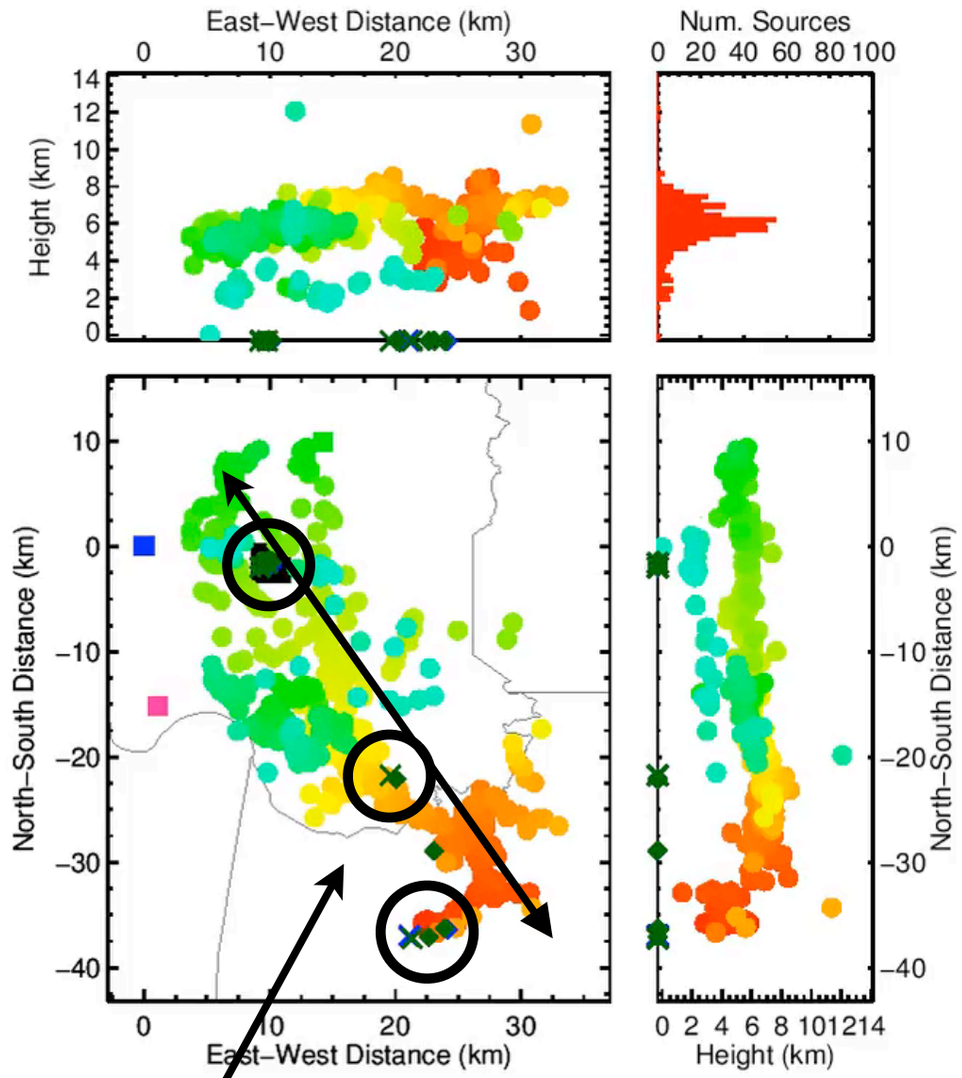
Some leaders can go up! WAFF Tower

2013/04/28 08:47:16

Electric field



60 km long discharge!



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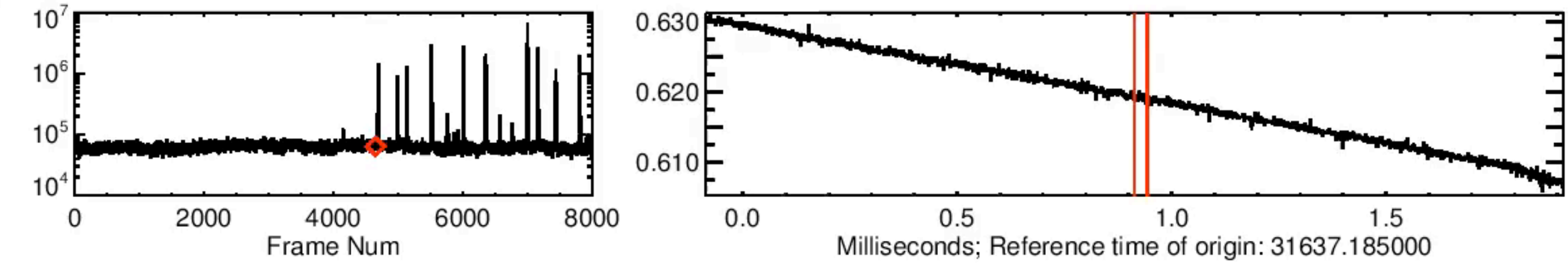
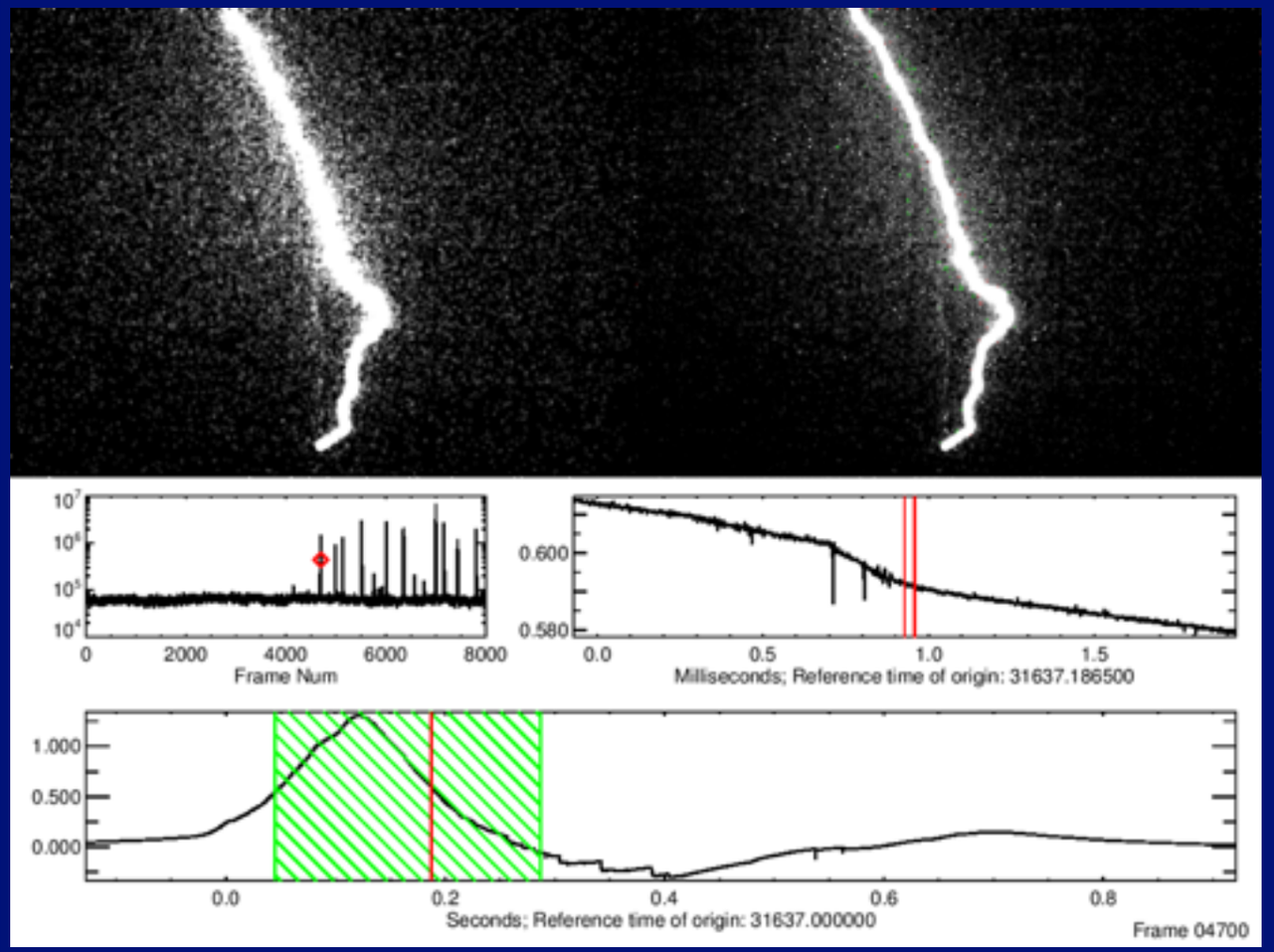
Stop time:	31637.348065
Time Elapsed:	0.625000

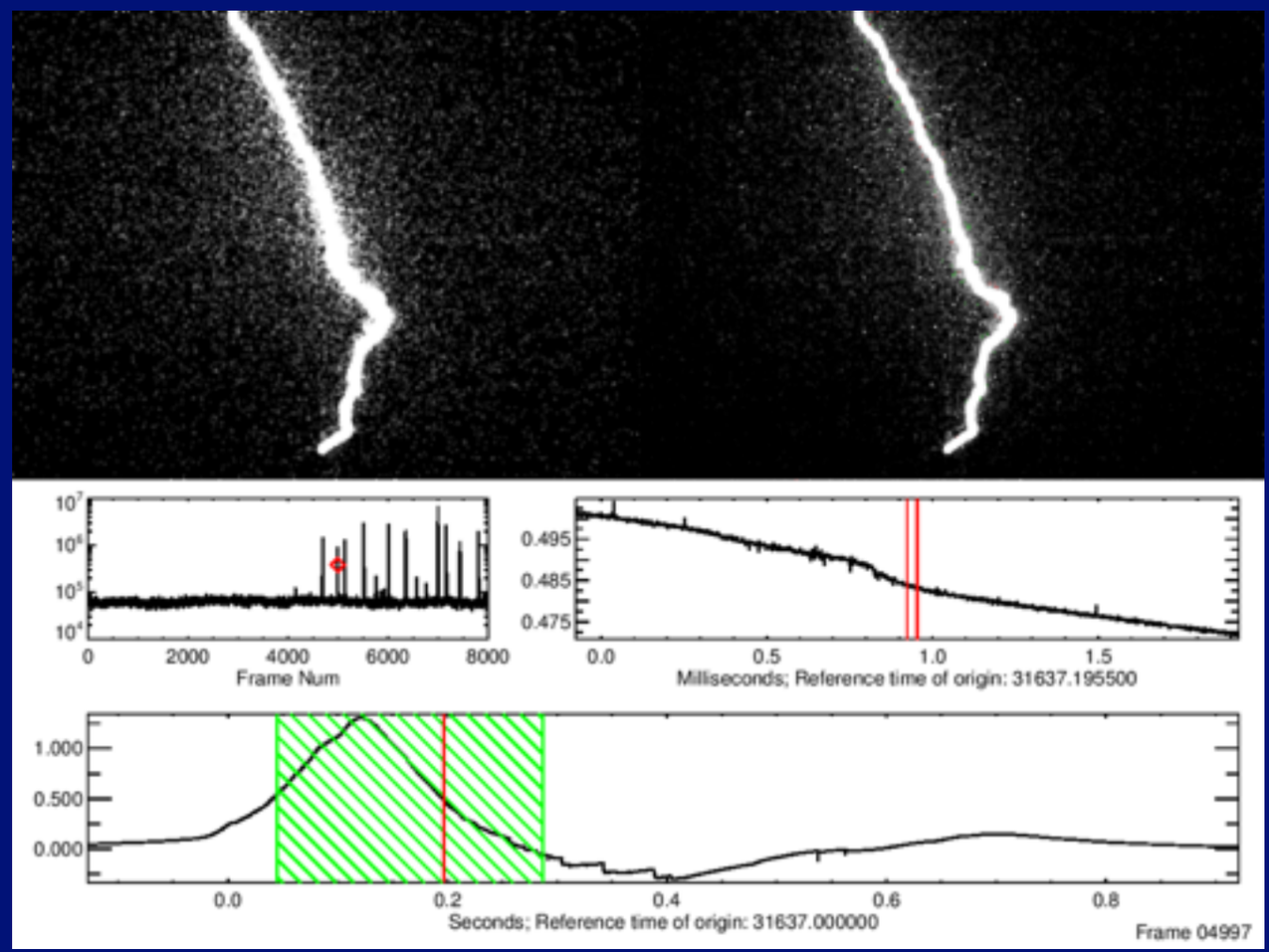
Local Network (VHF)

Left channel

Right channel




Frame Num
Milliseconds; Reference time of origin: 31637.186500
Seconds; Reference time of origin: 31637.000000
Frame 04700


Frame Num
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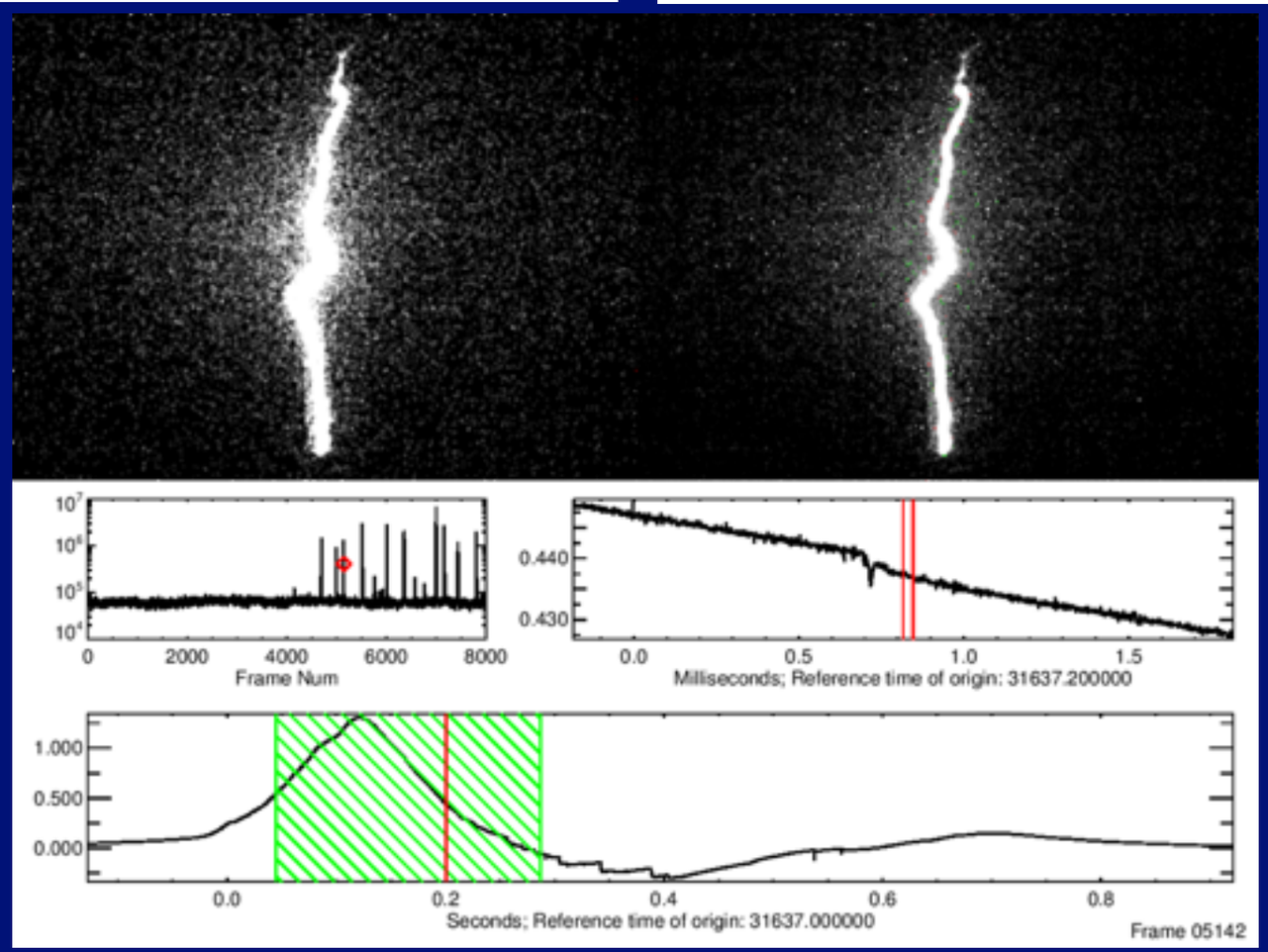
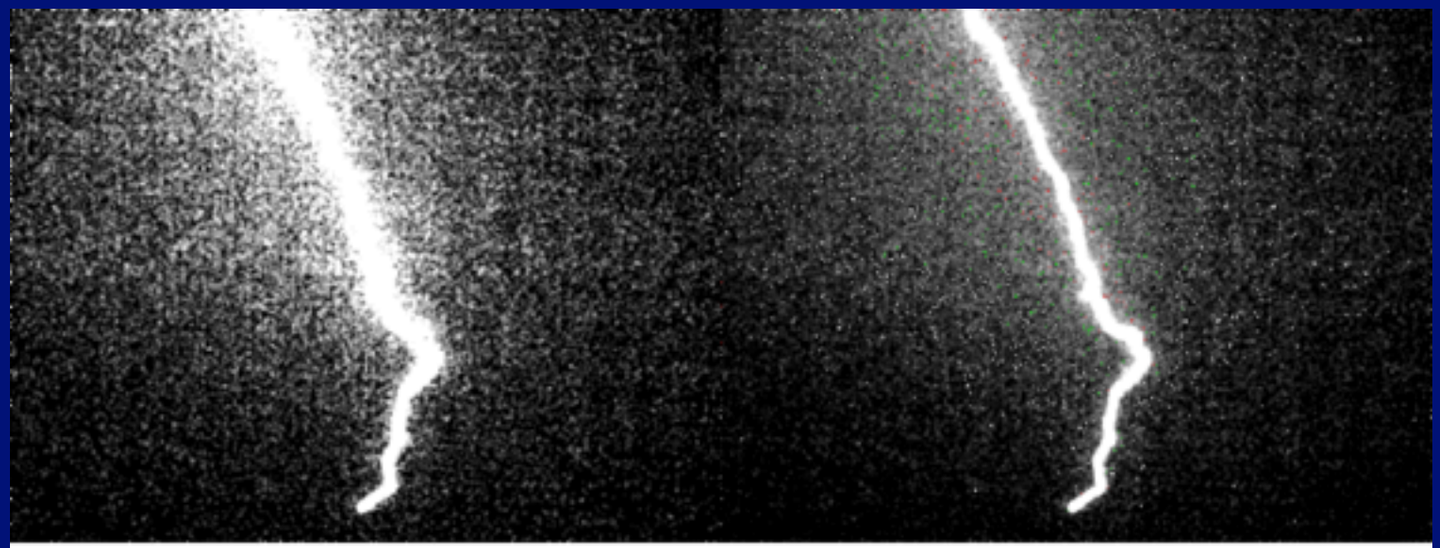
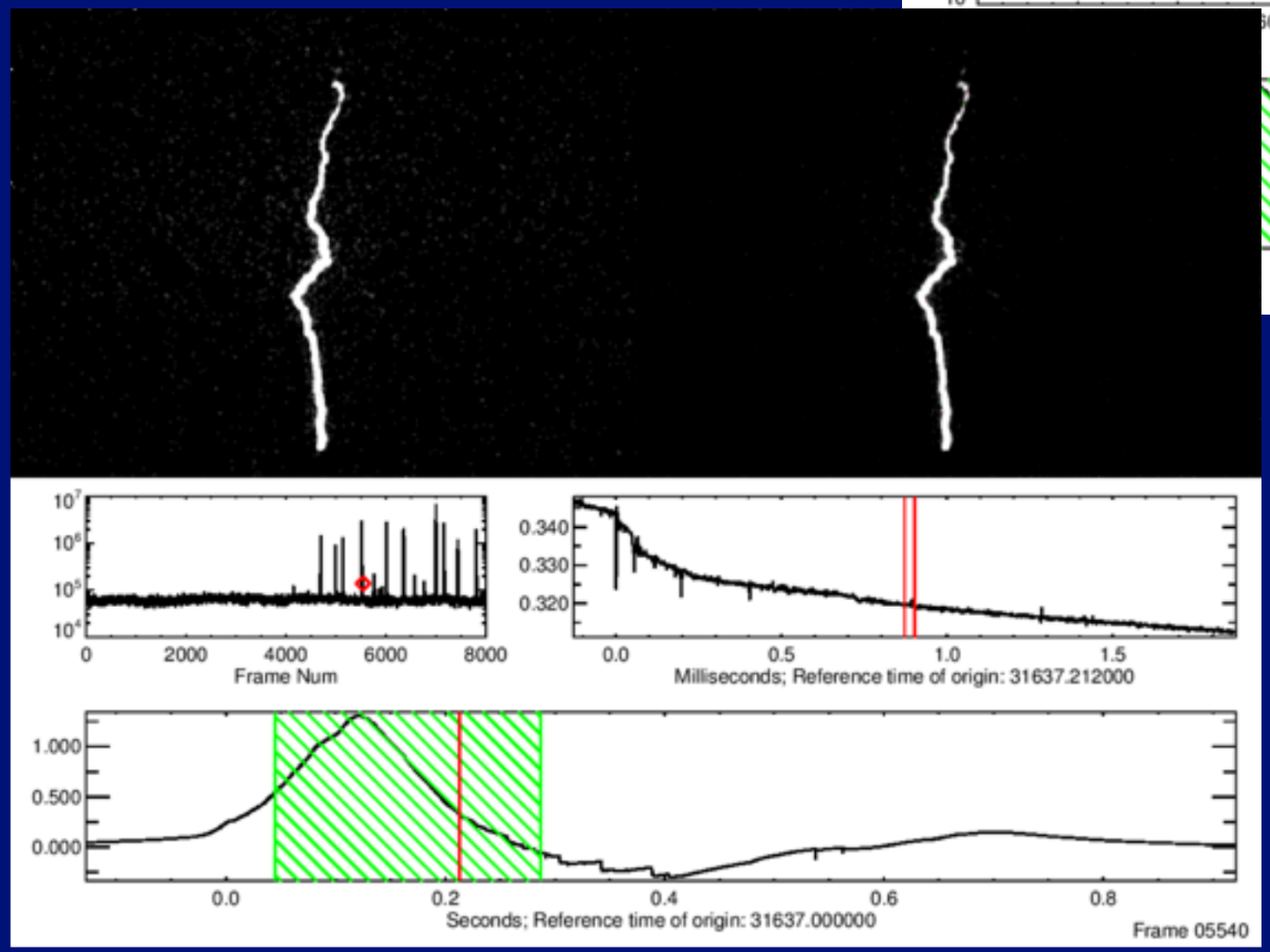
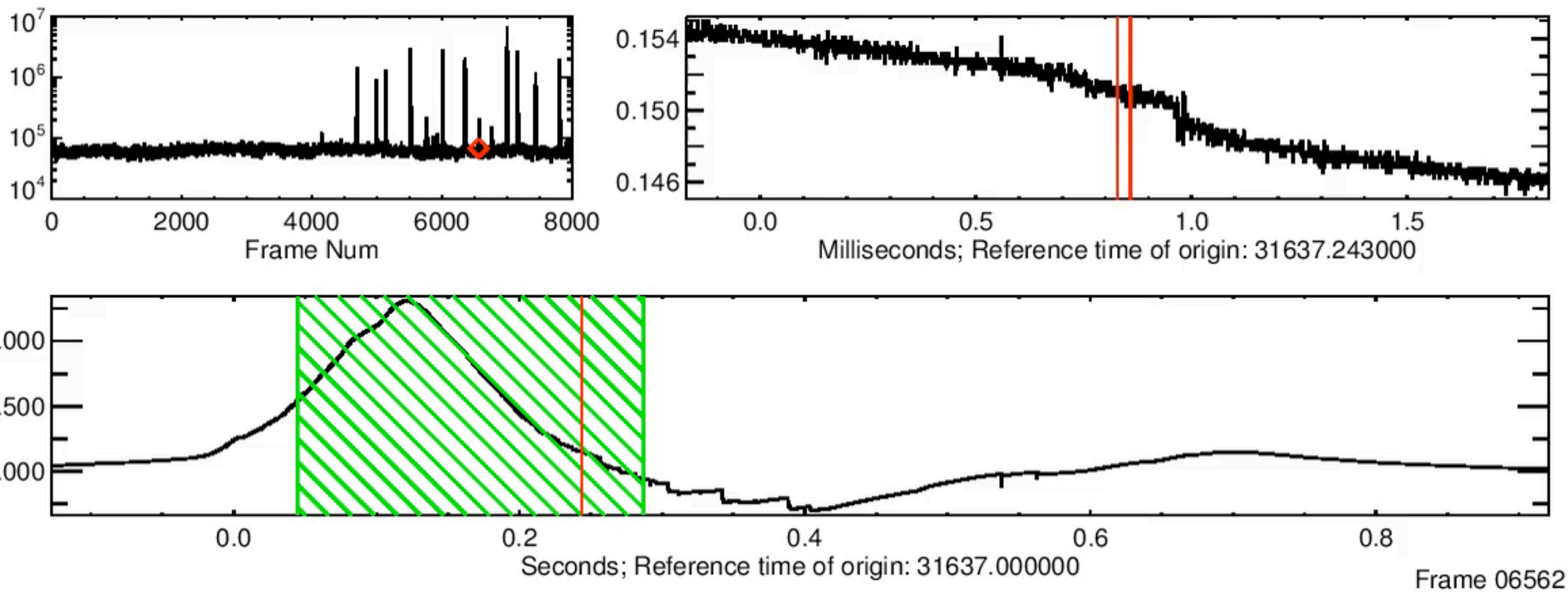
Seconds; Reference time of origin: 31637.000000
Frame 04997

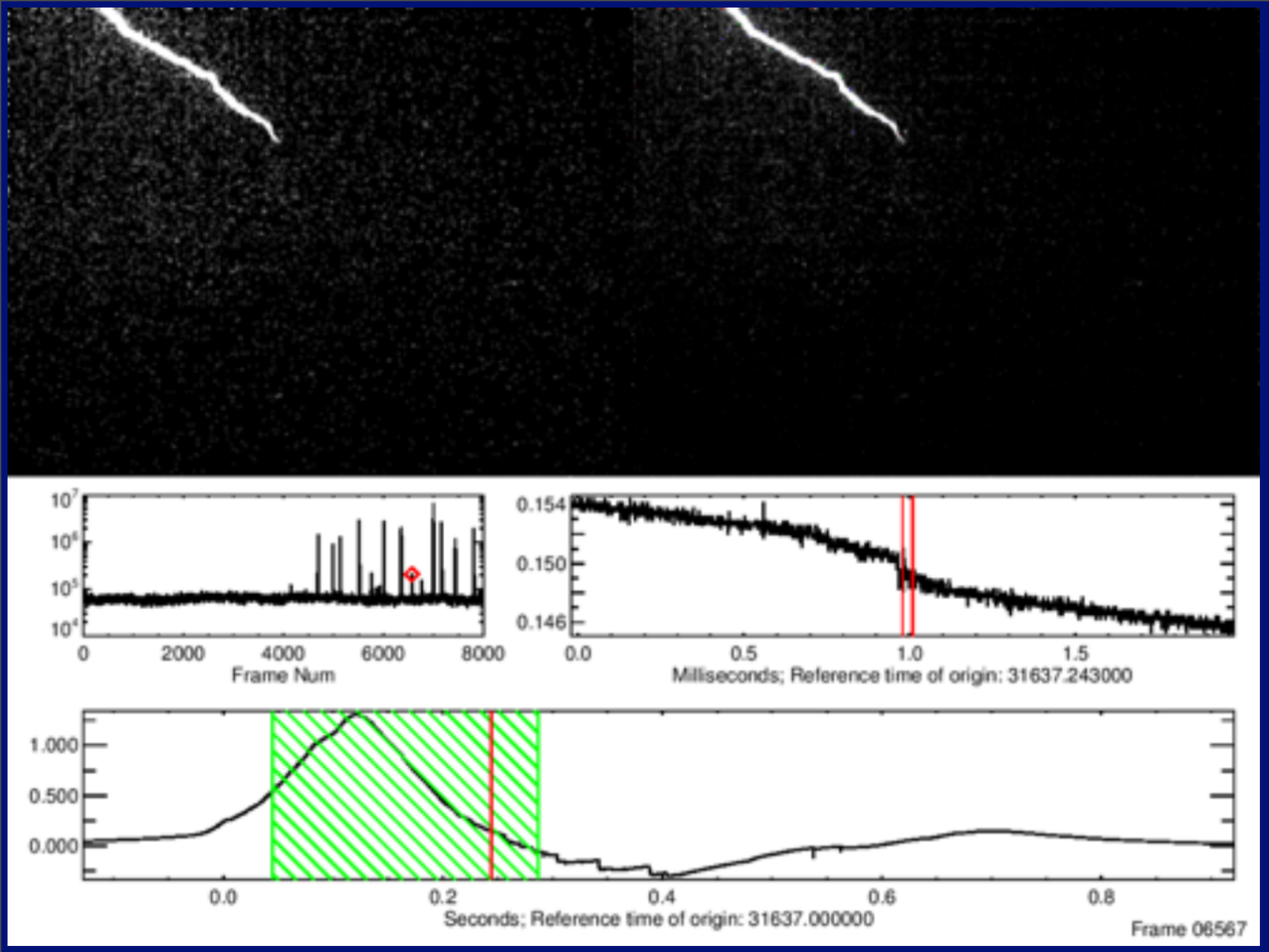

Frame Num
Milliseconds; Reference time of origin: 31637.200000
Seconds; Reference time of origin: 31637.000000
Frame 05142

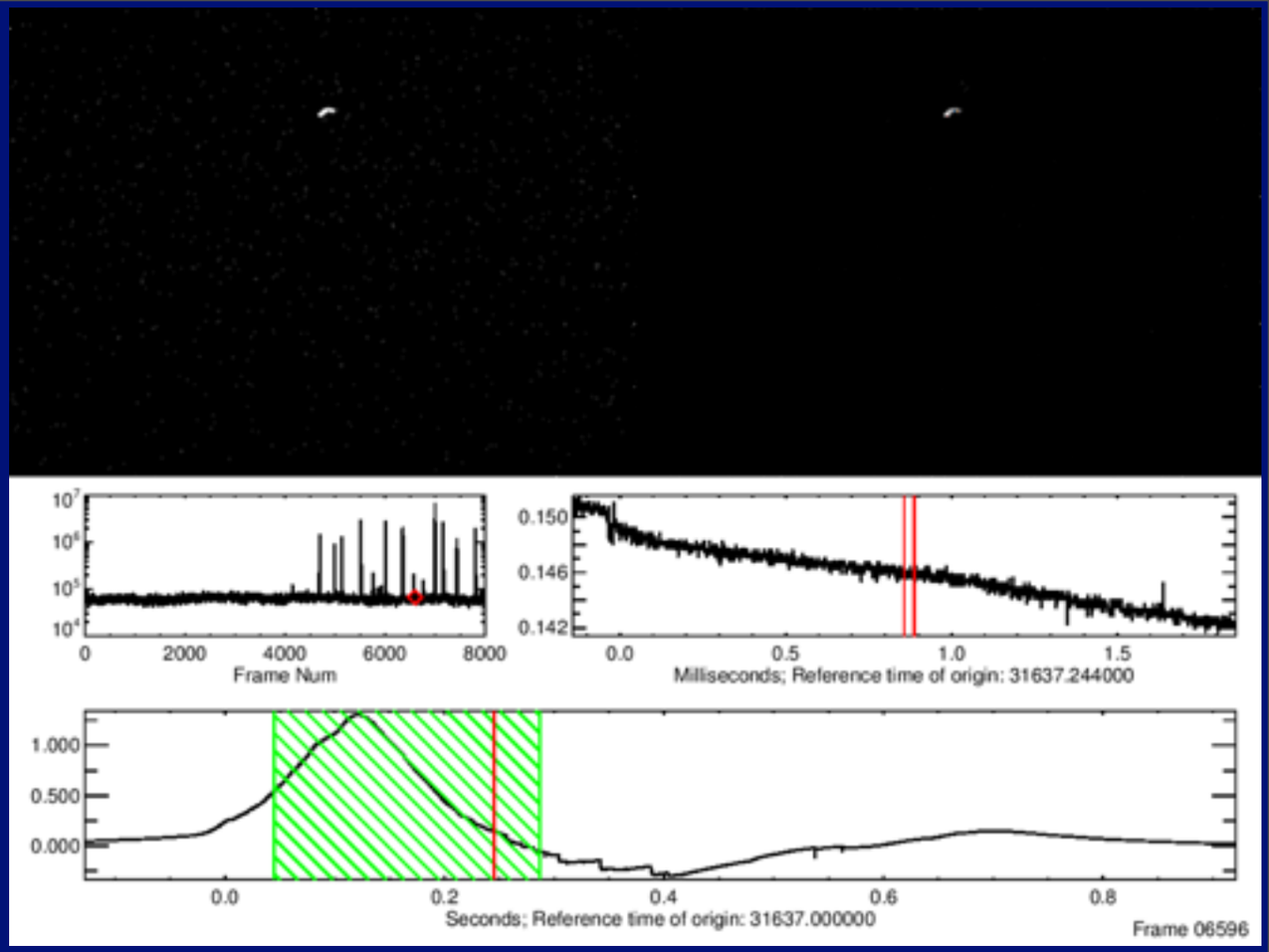

10^7
10^6
10^5
10^4
8000
0.340
0.320
0.0
0.5
1.0
1.5
Milliseconds; Reference time of origin: 31637.211500
0.2
0.4
0.6
0.8
Seconds; Reference time of origin: 31637.000000
Frame 05517


10^7
10^6
10^5
10^4
0
2000
4000
6000
8000
Frame Num
0.340
0.330
0.320
0.0
0.5
1.0
1.5
Milliseconds; Reference time of origin: 31637.212000
1.000
0.500
0.000
0.0
0.2
0.4
0.6
0.8
Seconds; Reference time of origin: 31637.000000
Frame 05540

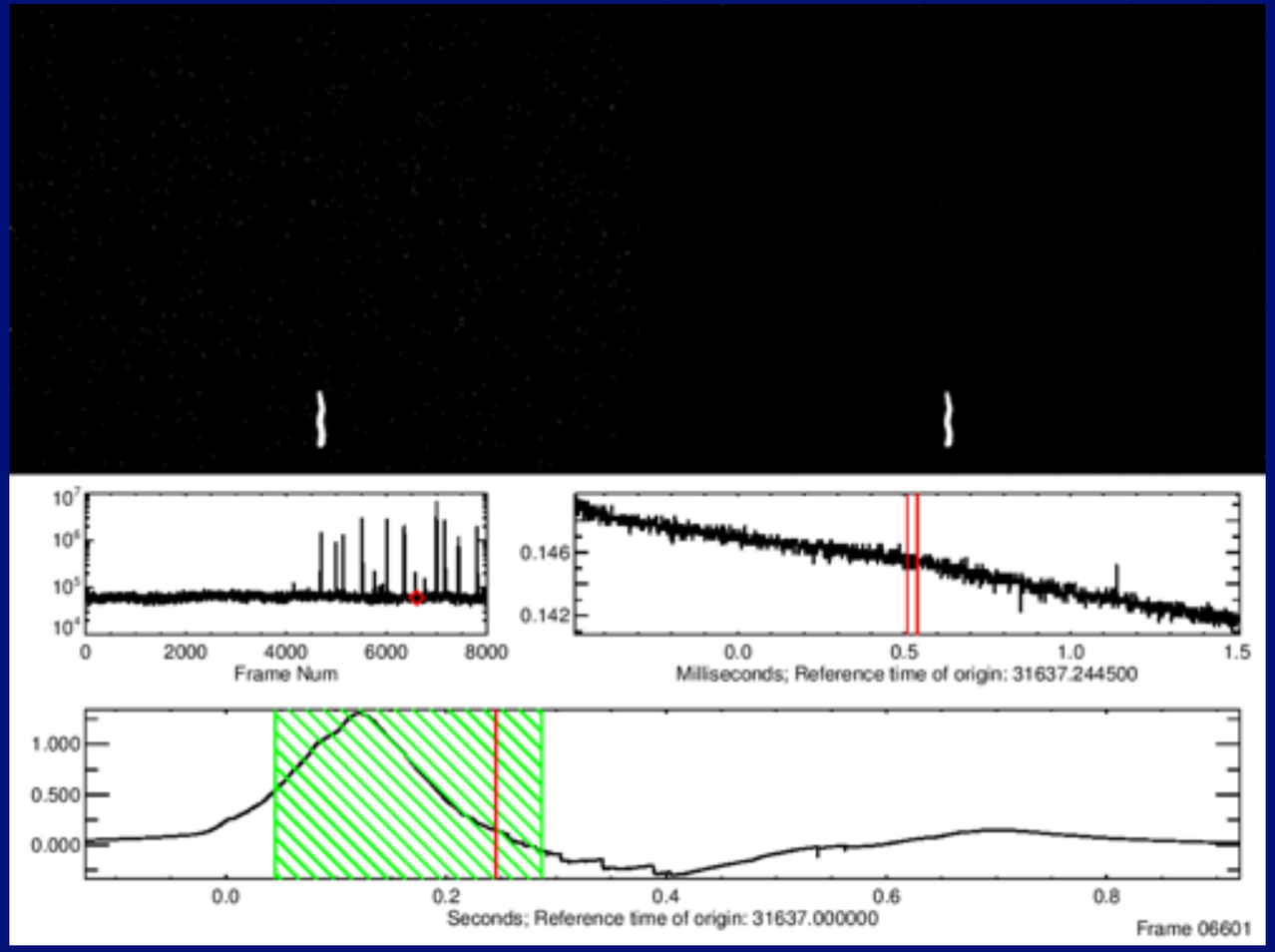

10^7
10^6
10^5
10^4
0
2000
4000
6000
8000
Frame Num
0.154
0.150
0.146
0.0
0.5
1.0
1.5
Milliseconds; Reference time of origin: 31637.243000
1.000
0.500
0.000
0.0
0.2
0.4
0.6
0.8
Seconds; Reference time of origin: 31637.000000
Frame 06562

t=0



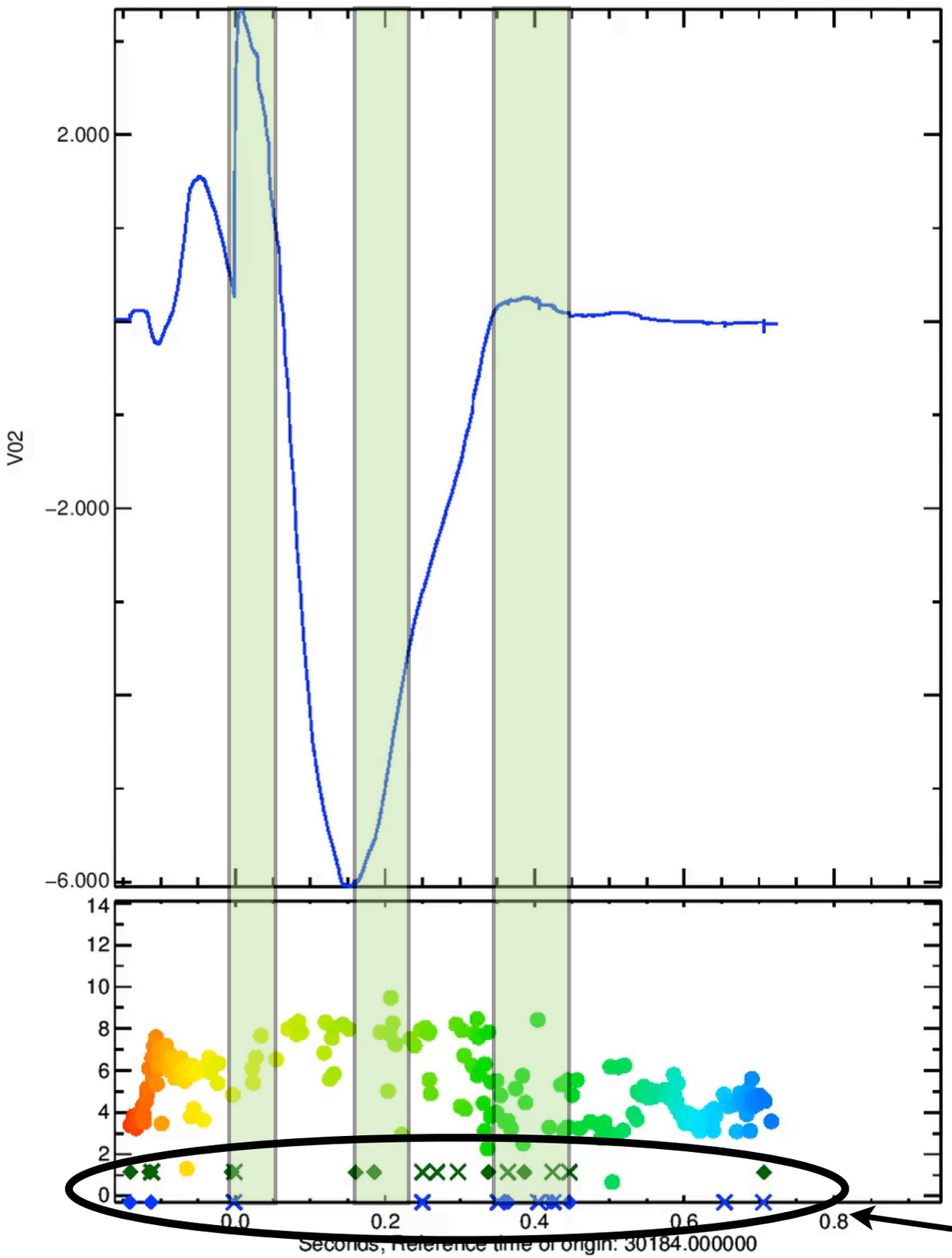


t=0.90 msec

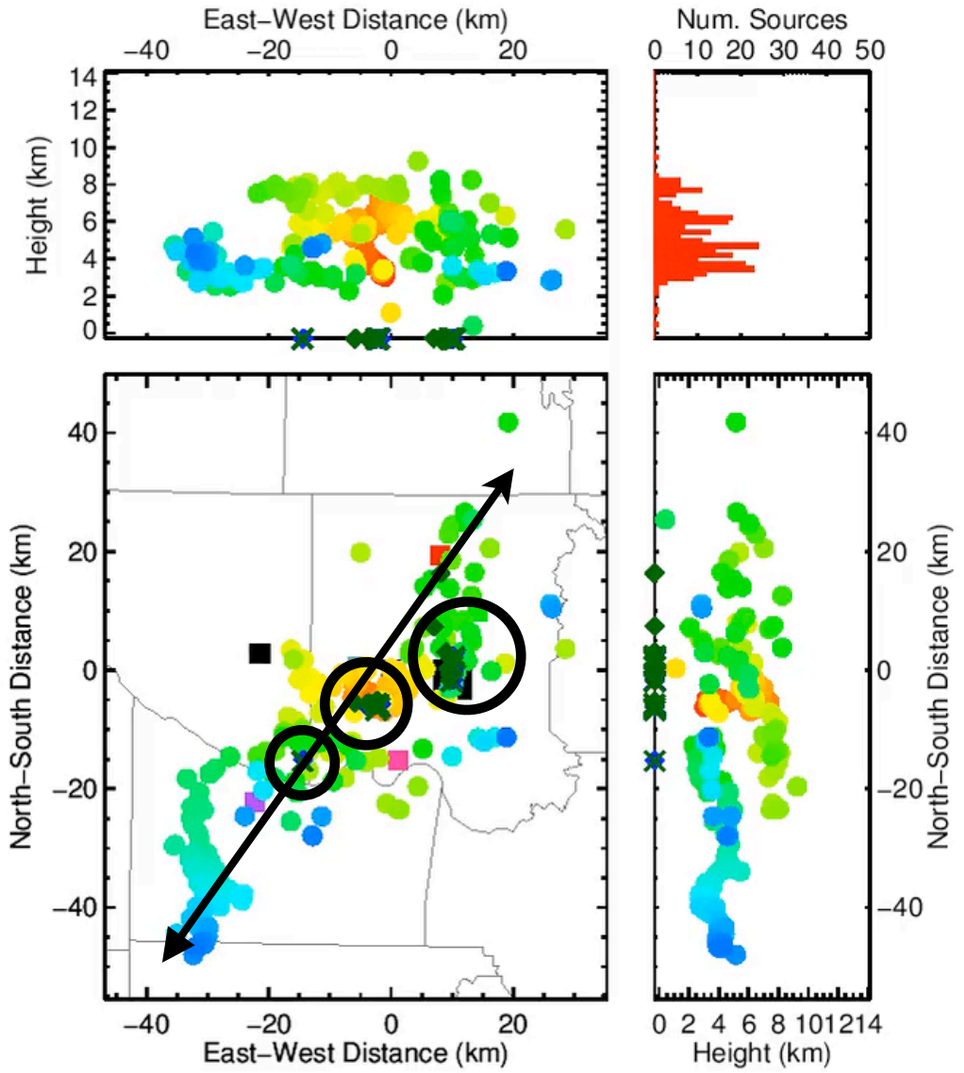


t=1.05 msec

2013/04/28 08:23:03



100 km long discharge!



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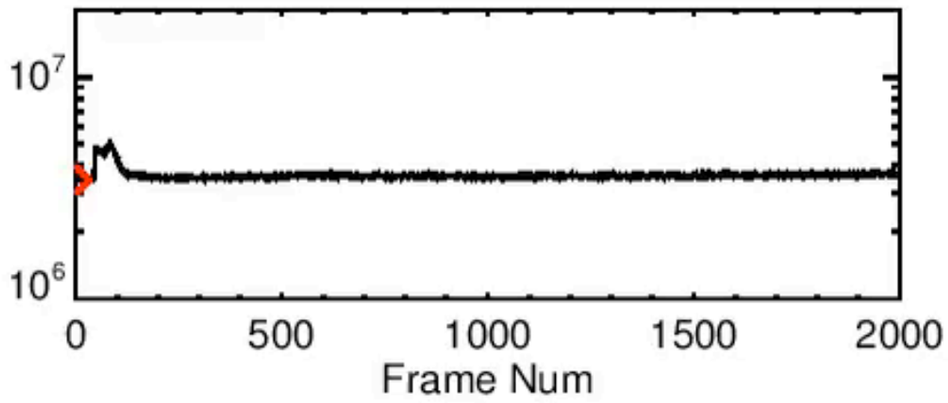
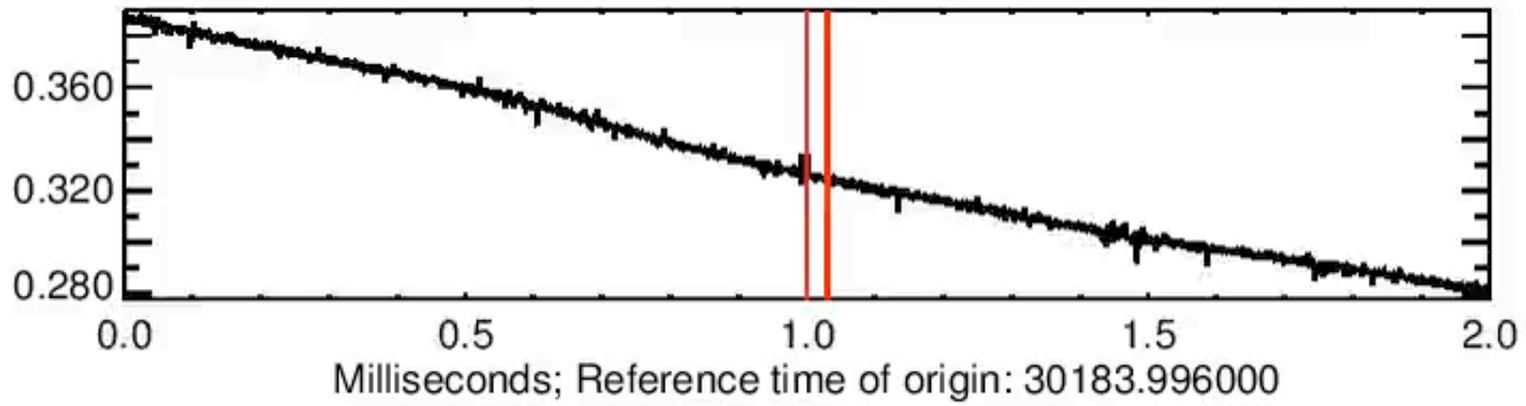
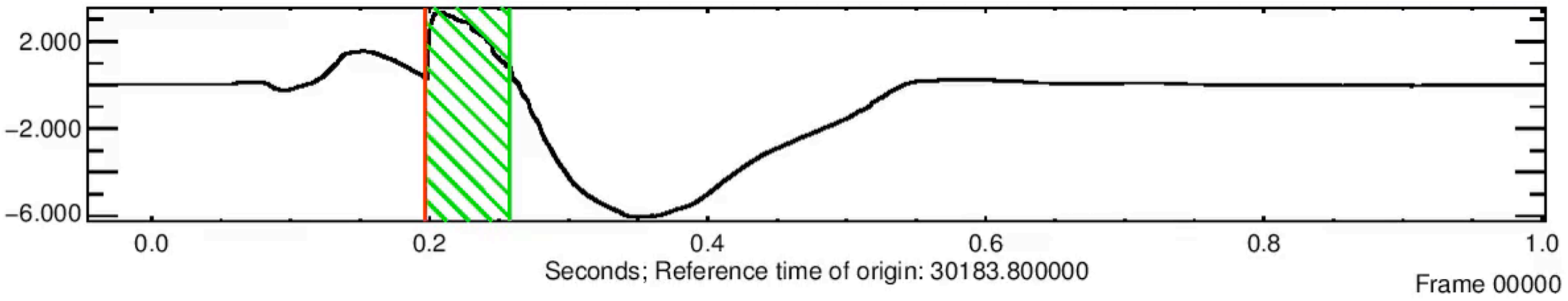
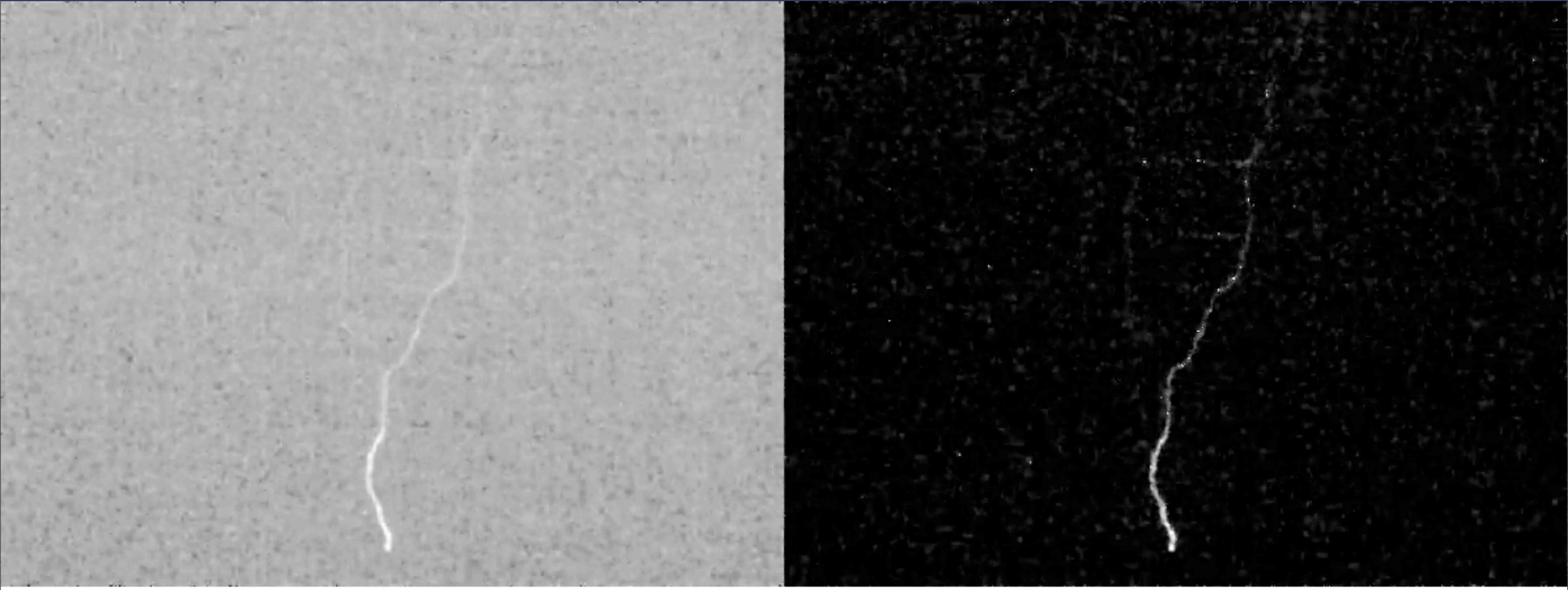
Stop time:	30184.723680
Time Elapsed:	0.885000

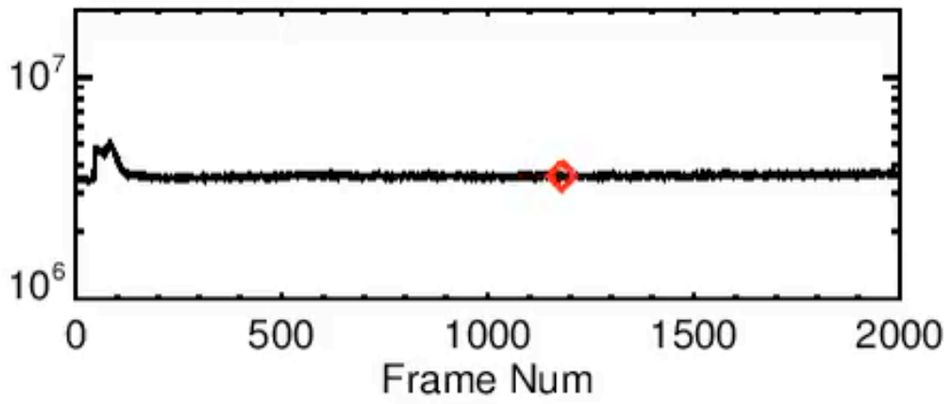
National network (VLF)

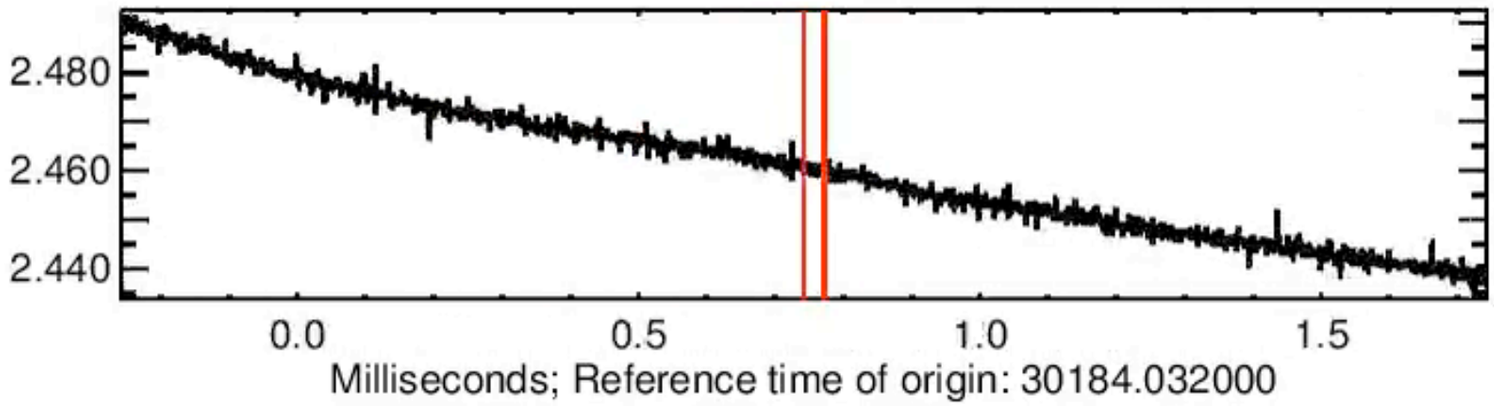

10^7
10^6
0
500
1000
1500
2000
Frame Num

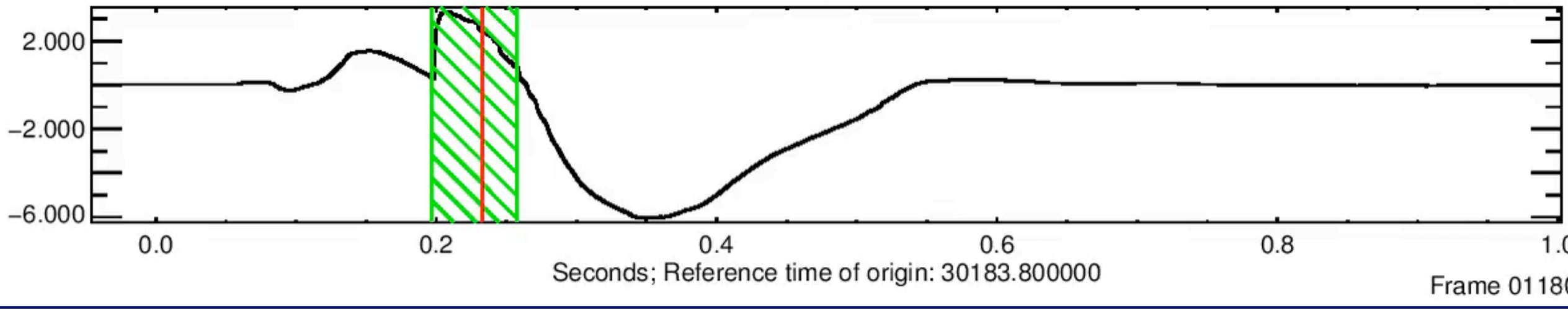

0.360
0.320
0.280
0.0
0.5
1.0
1.5
2.0
Milliseconds; Reference time of origin: 30183.996000


2.000
−2.000
−6.000
0.0
0.2
0.4
0.6
0.8
1.0
Seconds; Reference time of origin: 30183.800000
Frame 00000

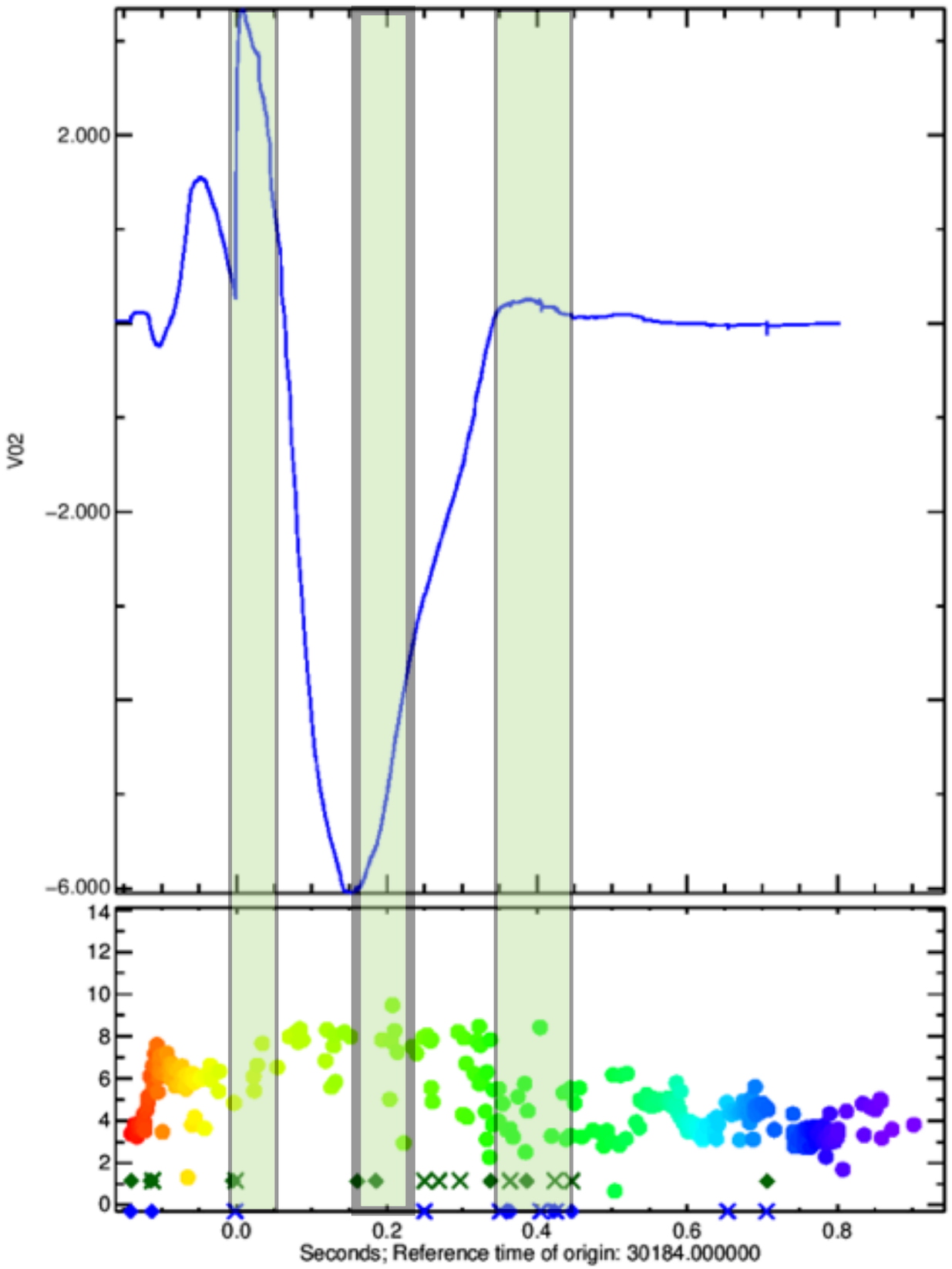



10^7
10^6
0
500
1000
1500
2000
Frame Num

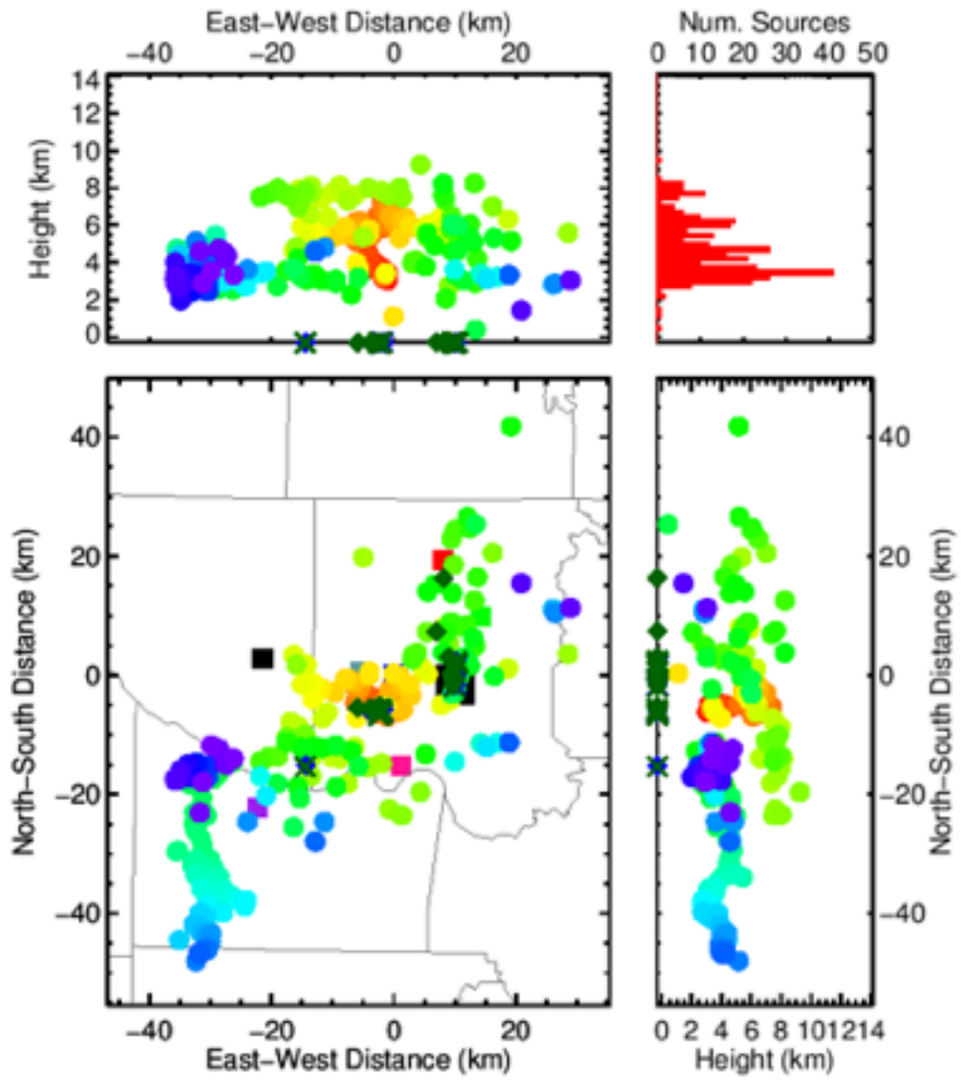

2.480
2.460
2.440
0.0
0.5
1.0
1.5
Milliseconds; Reference time of origin: 30184.032000


2.000
−2.000
−6.000
0.0
0.2
0.4
0.6
0.8
1.0
Seconds; Reference time of origin: 30183.800000
Frame 01180

2013/04/28 08:23:03



150 ms later....



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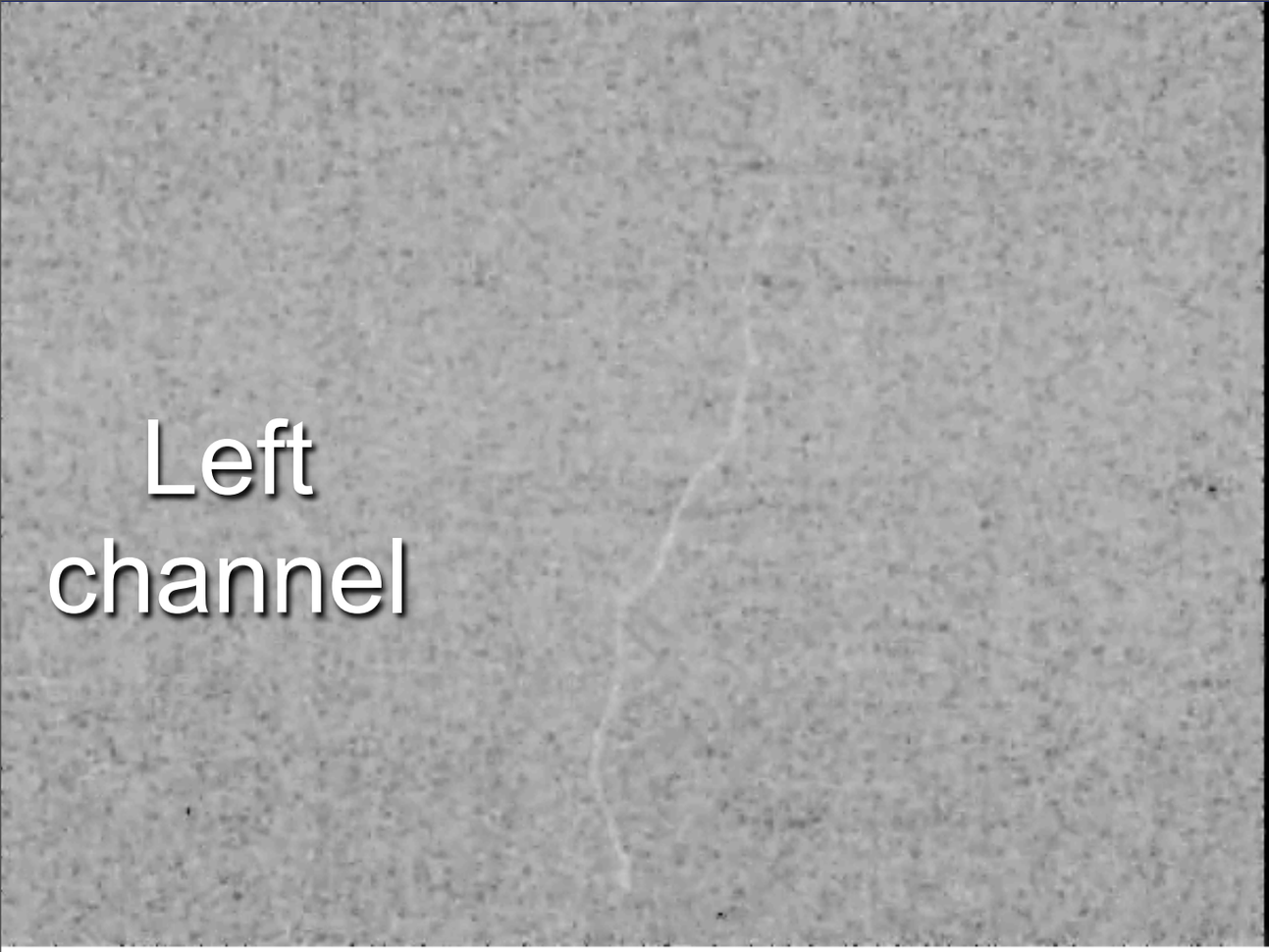
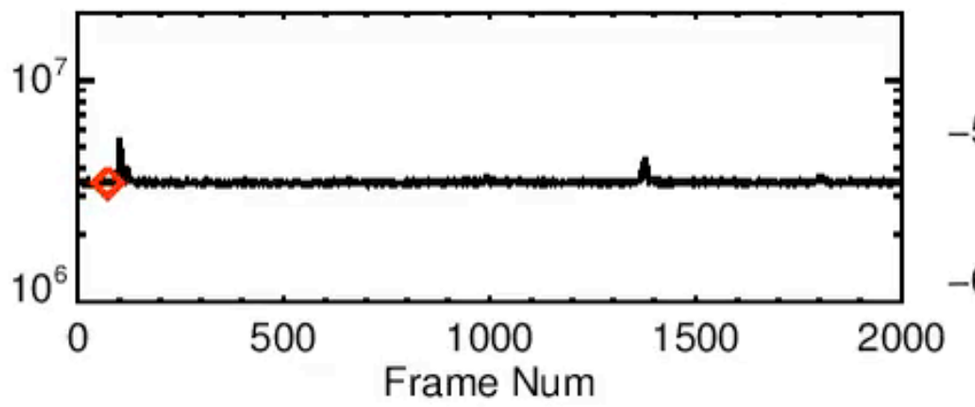
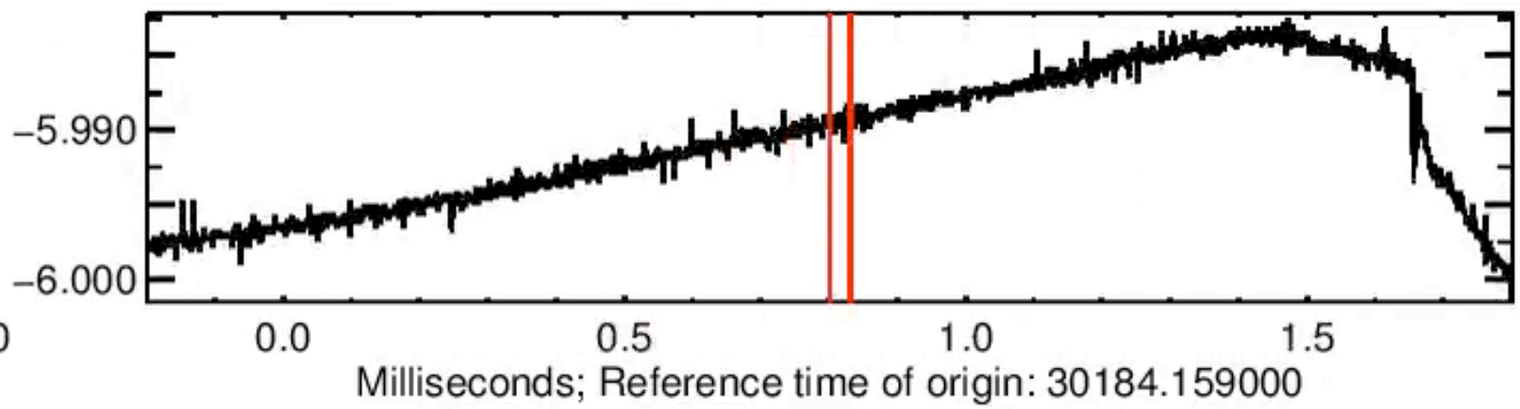
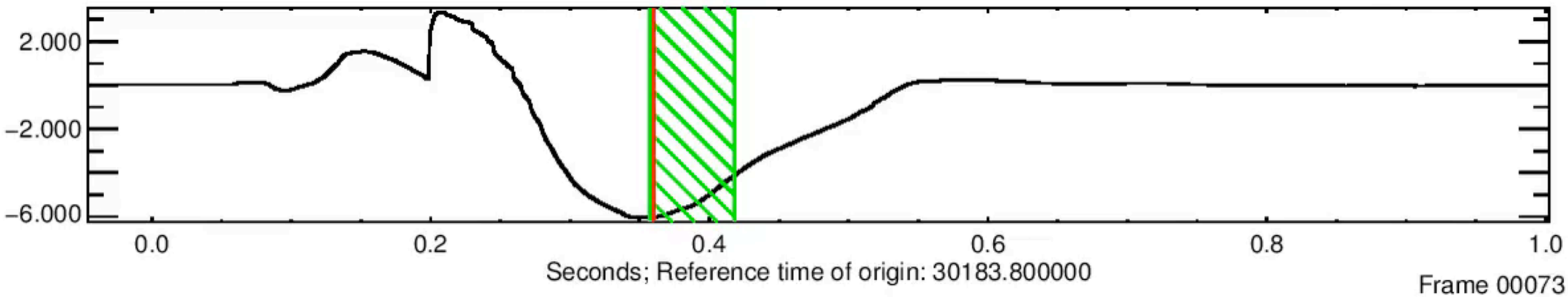
Time Elapsed:	1.070000

Left
channel

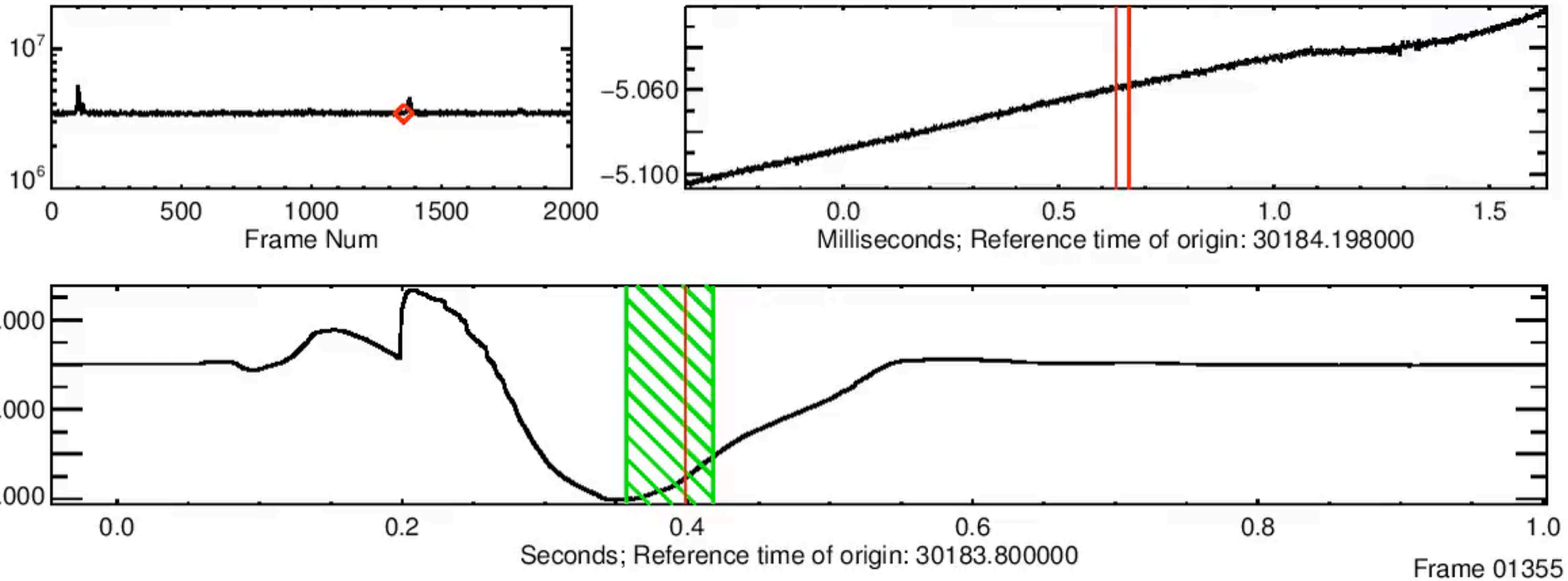




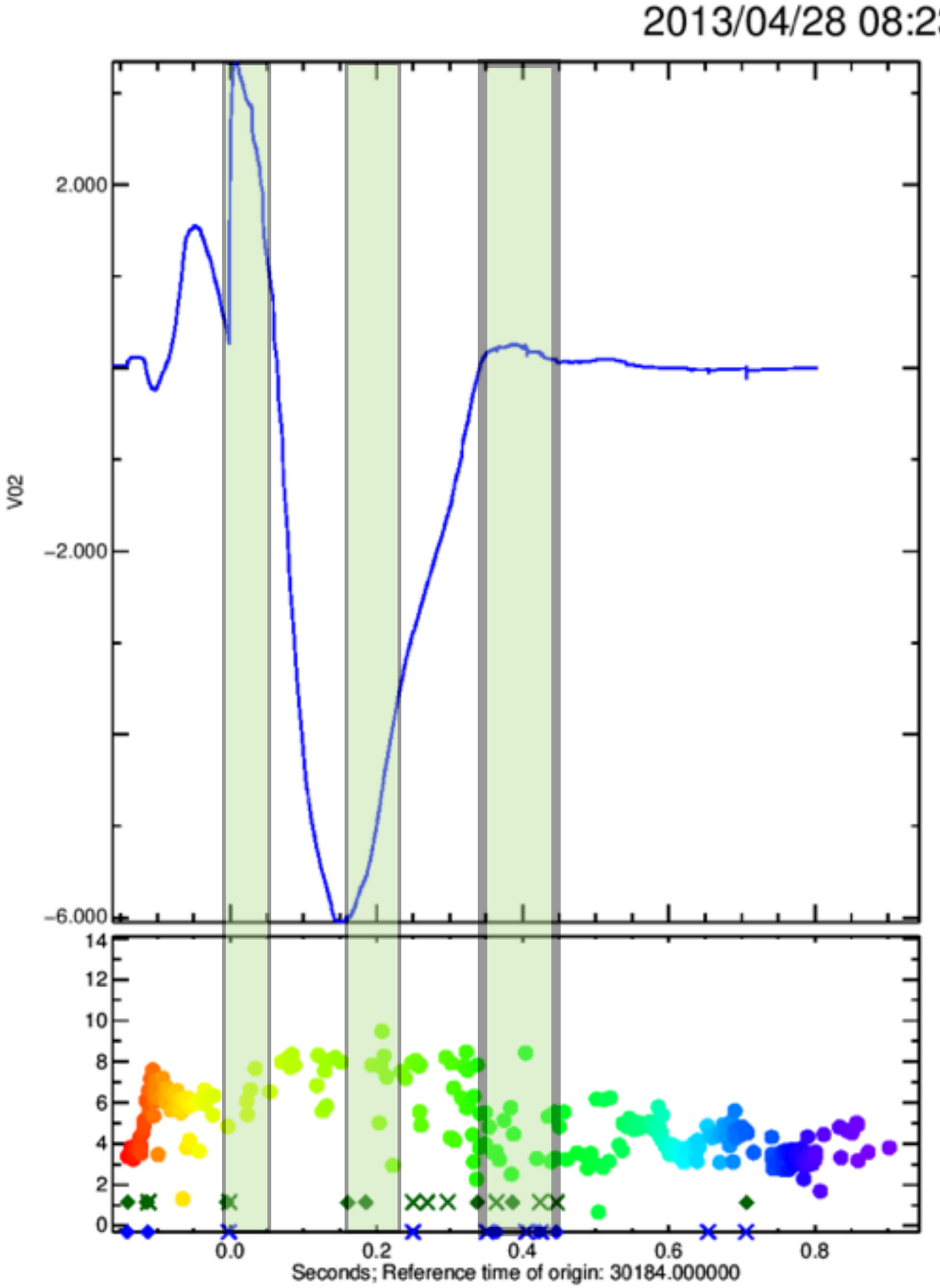


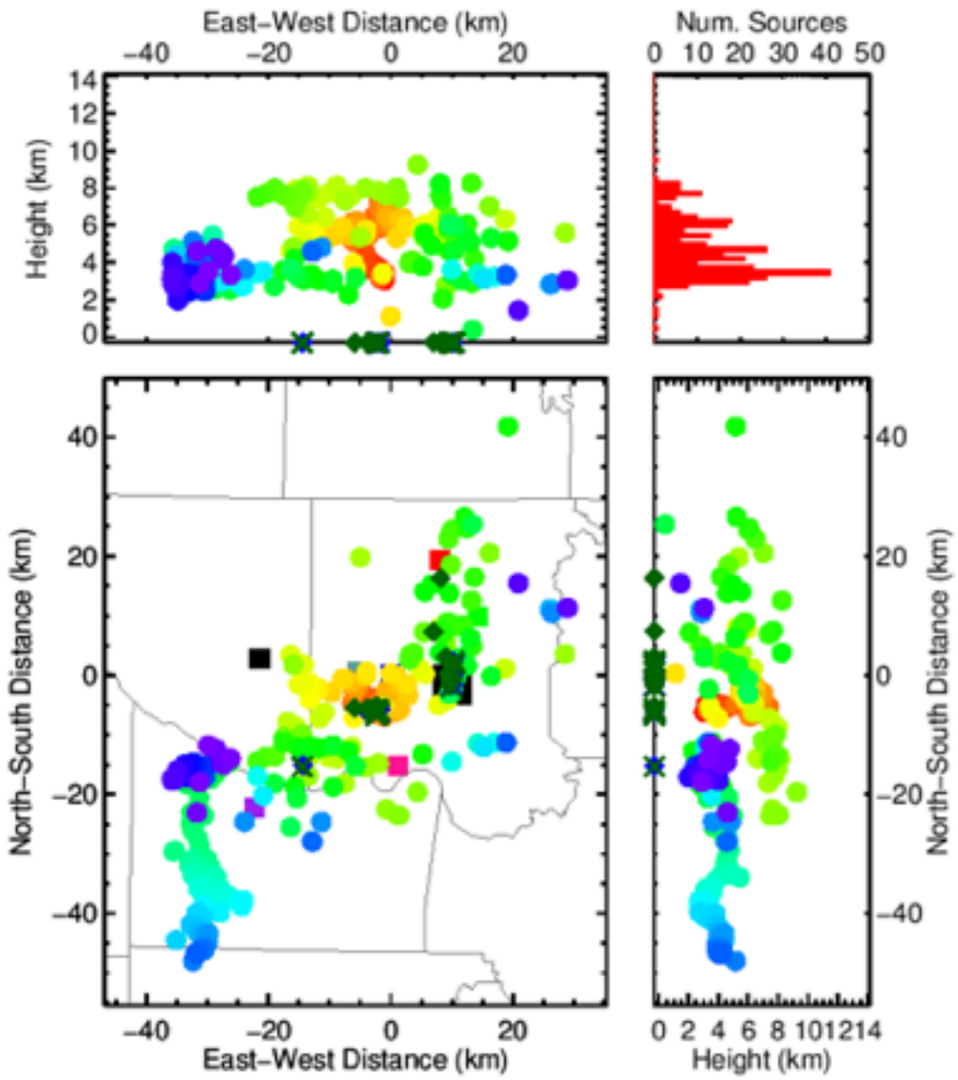


Left
channel



140 ms later....





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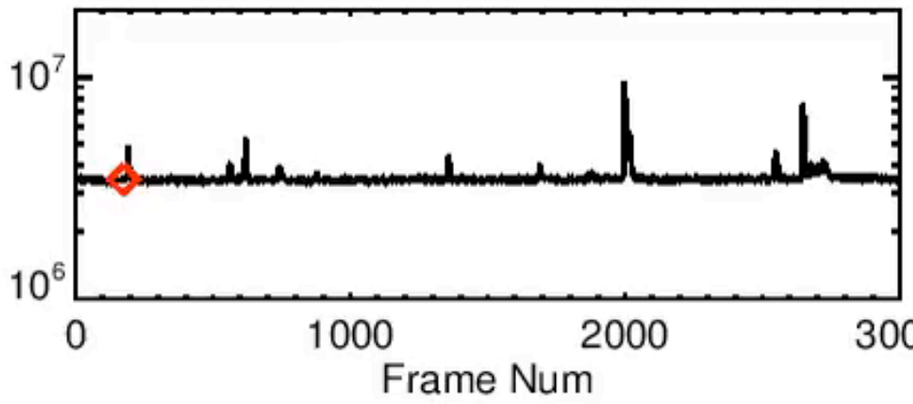
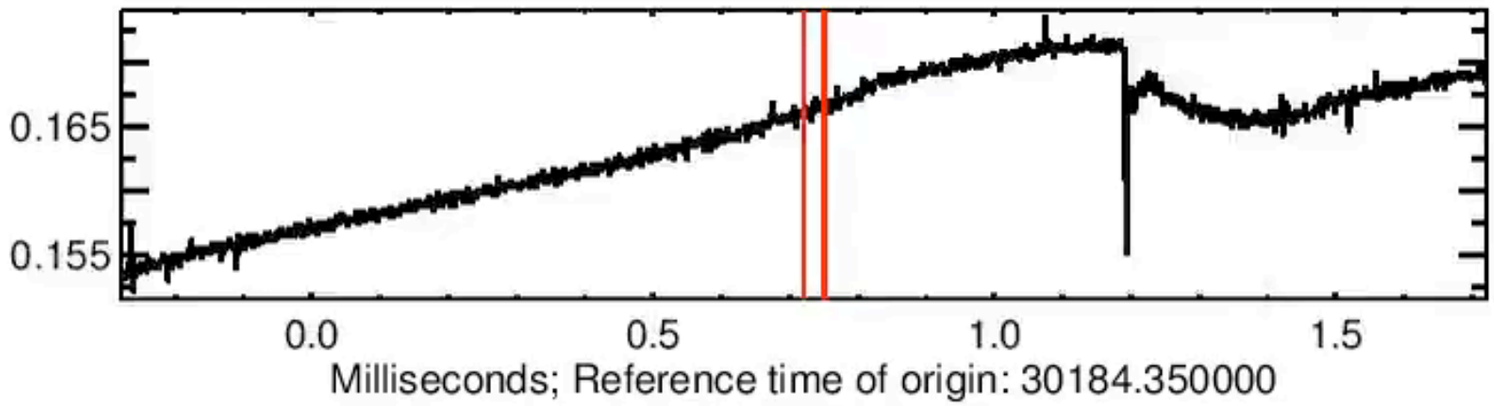
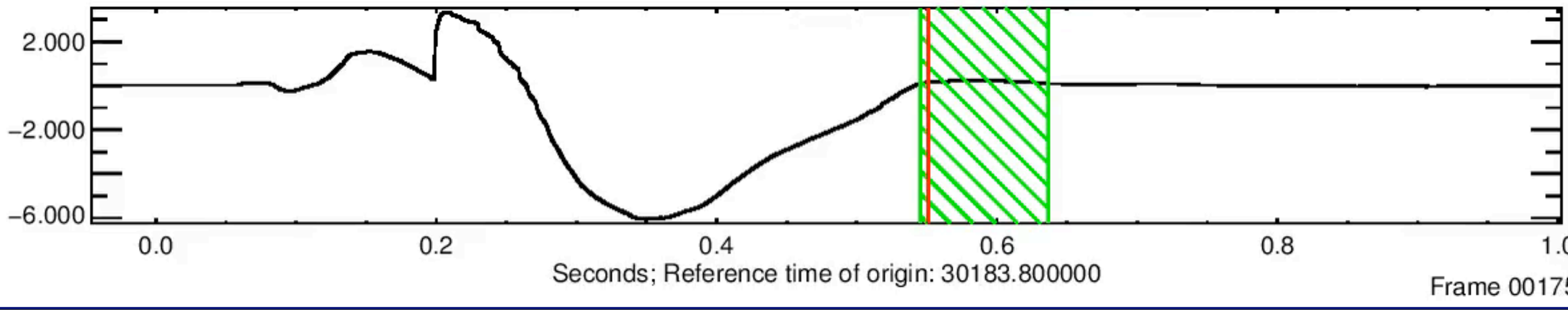
Stop time:	30184.908680
Time Elapsed:	1.070000

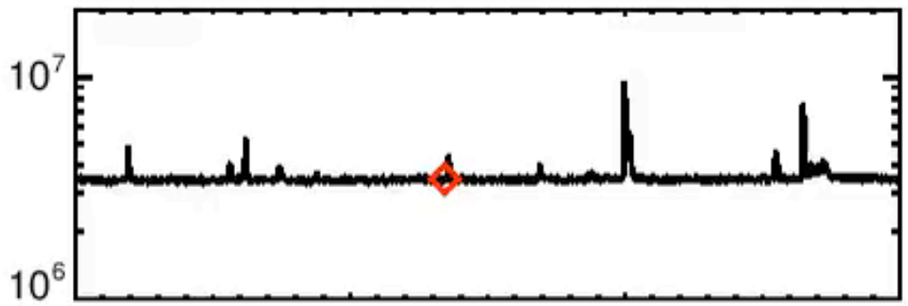
Right channel

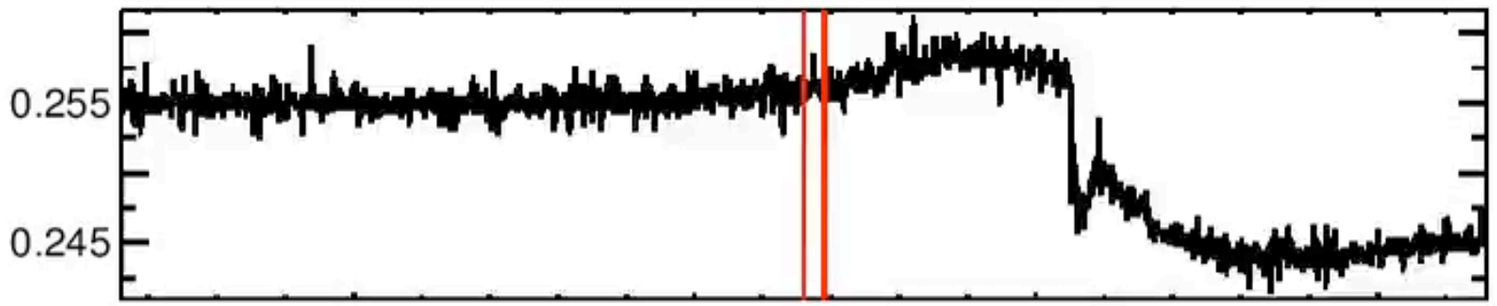


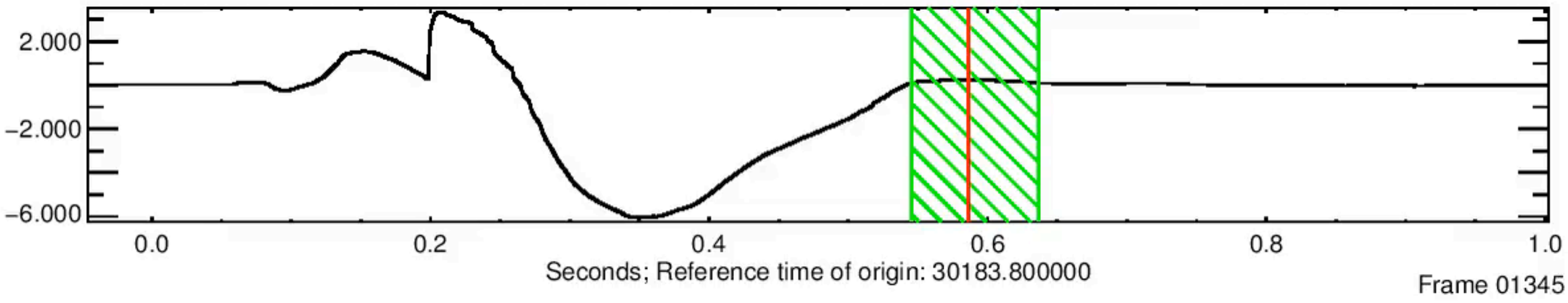


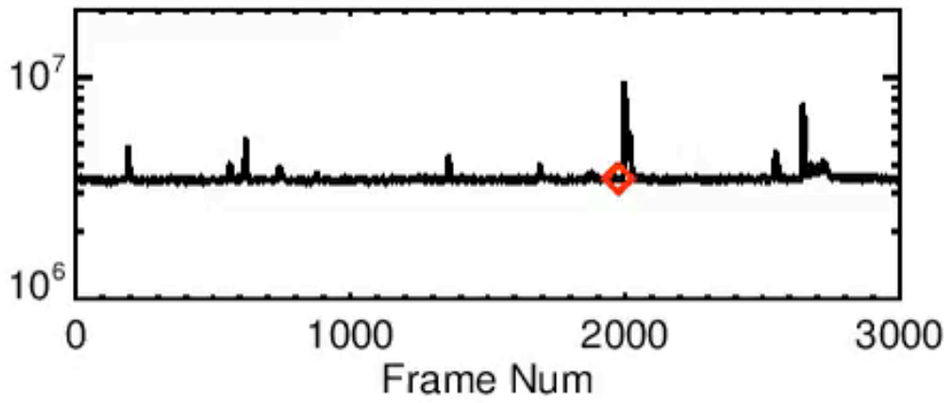


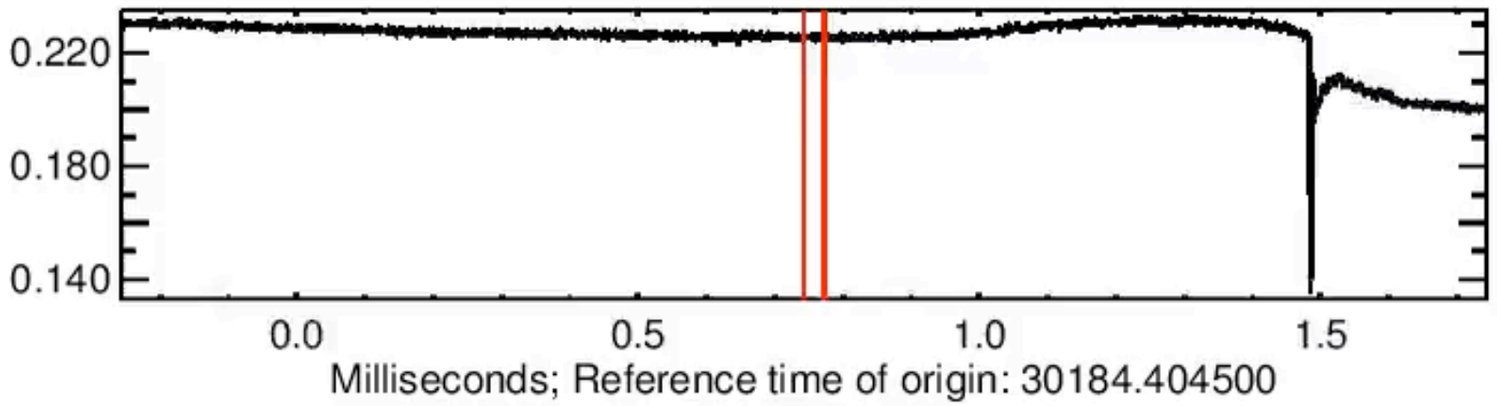
Discharge
over here
(WHNT)

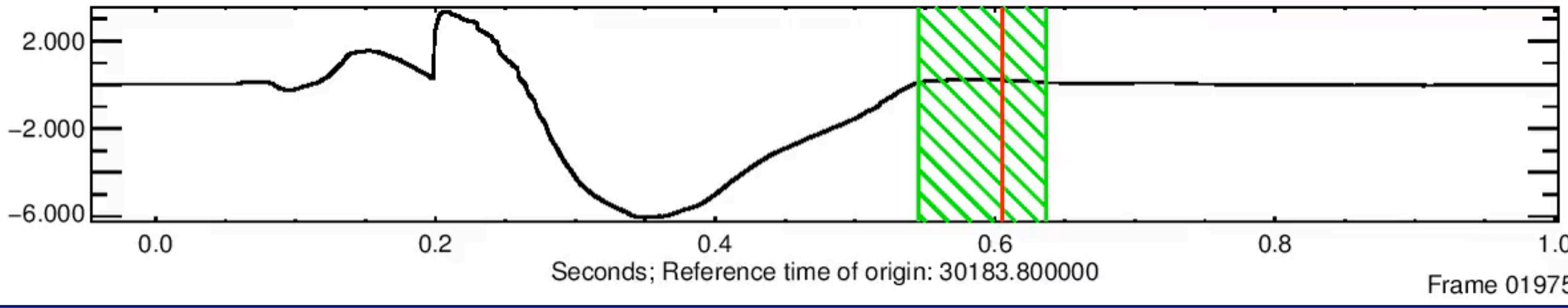






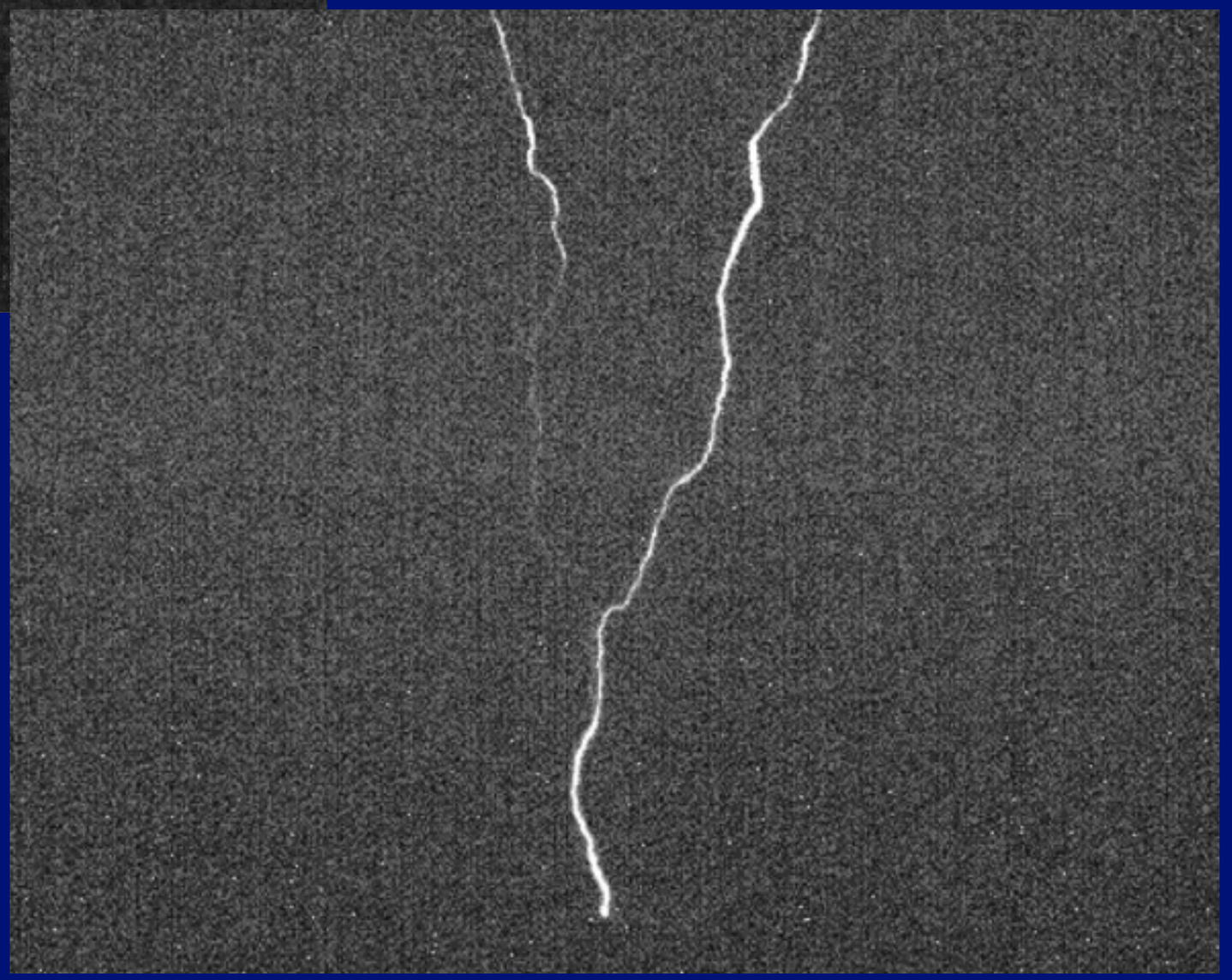

10^7
10^6
0
1000
2000
3000
Frame Num

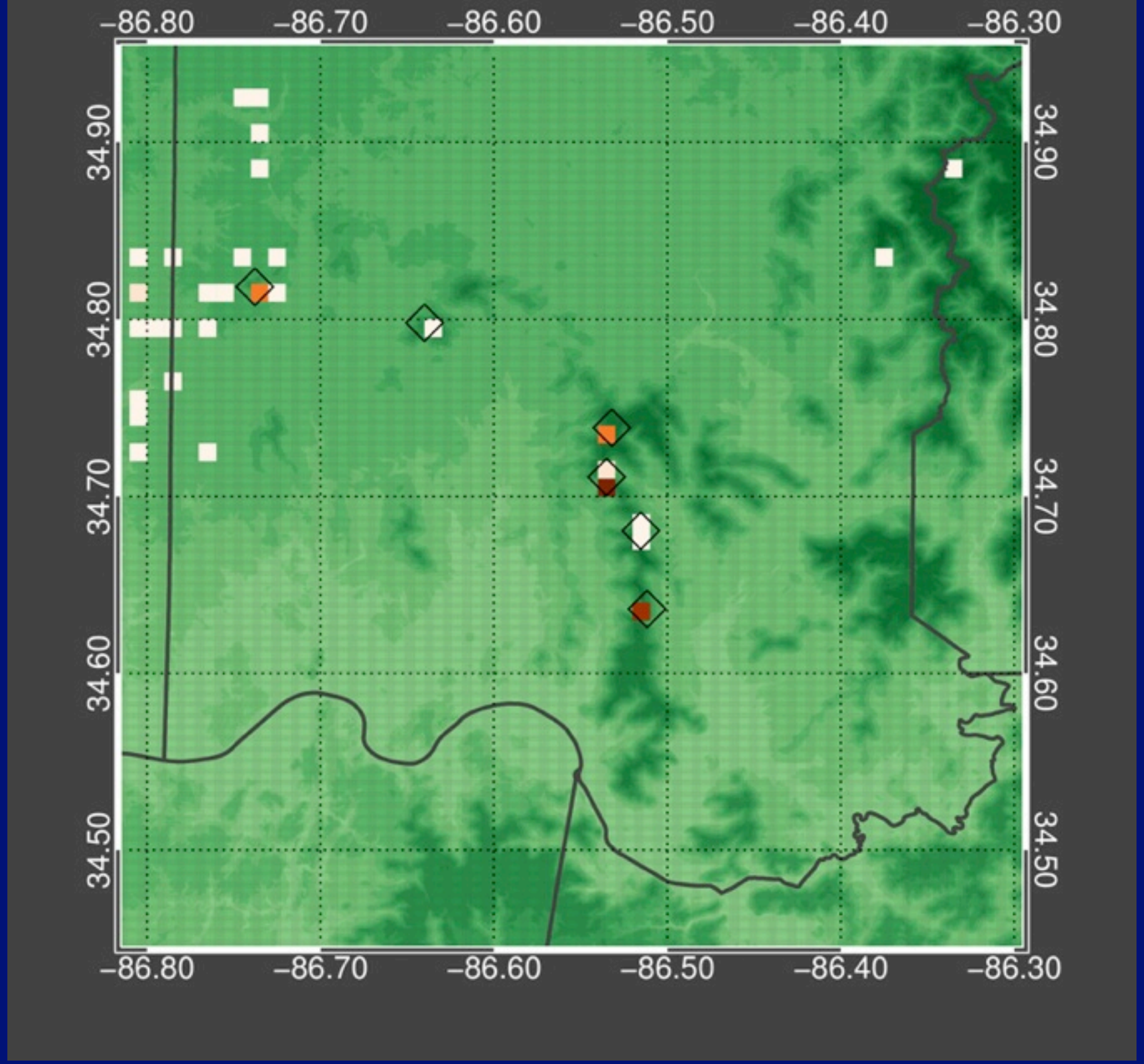

0.220
0.180
0.140
0.0
0.5
1.0
1.5
Milliseconds; Reference time of origin: 30184.404500


2.000
−2.000
−6.000
0.0
0.2
0.4
0.6
0.8
1.0
Seconds; Reference time of origin: 30183.800000
Frame 01975

negative leader?

positive leader?

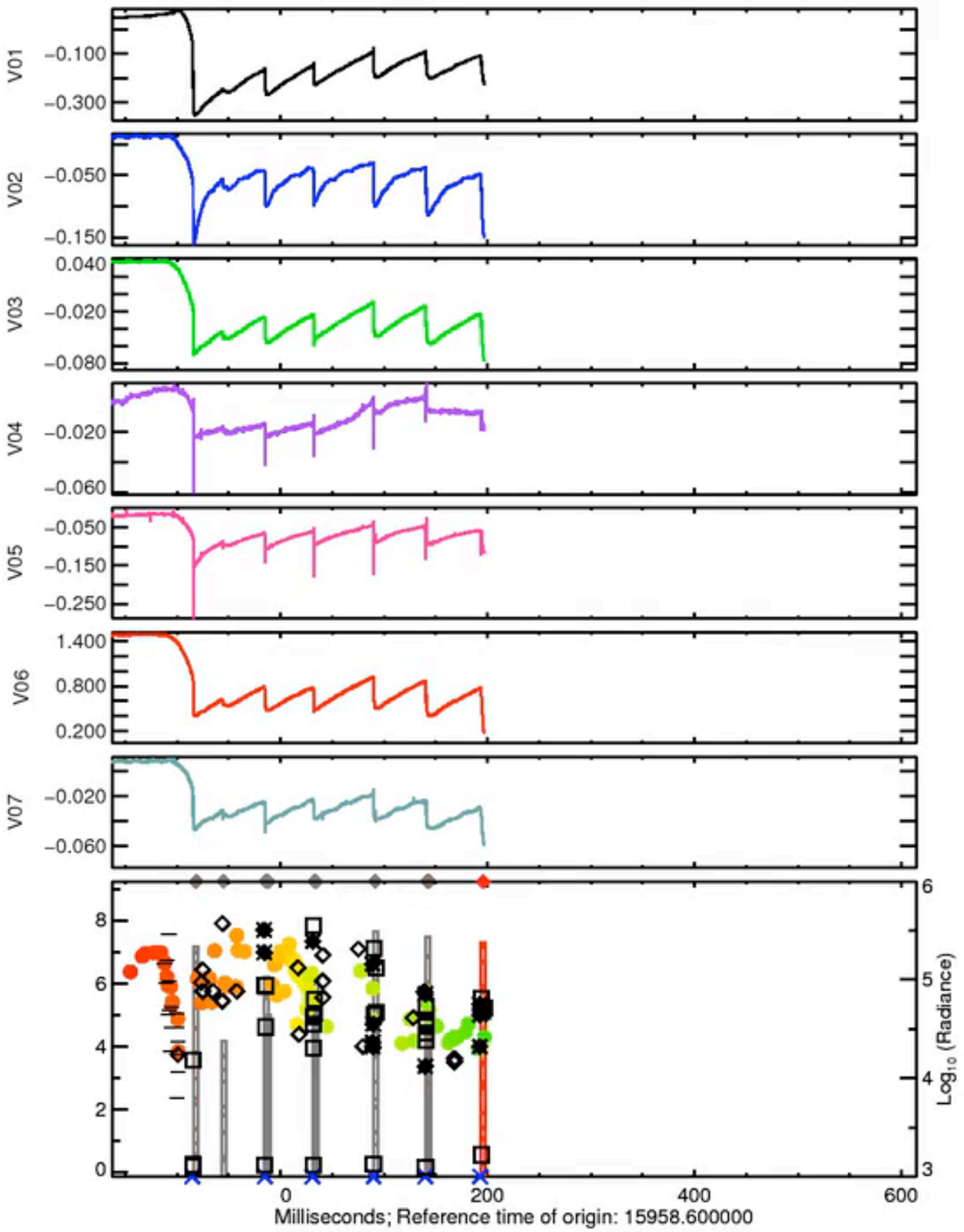


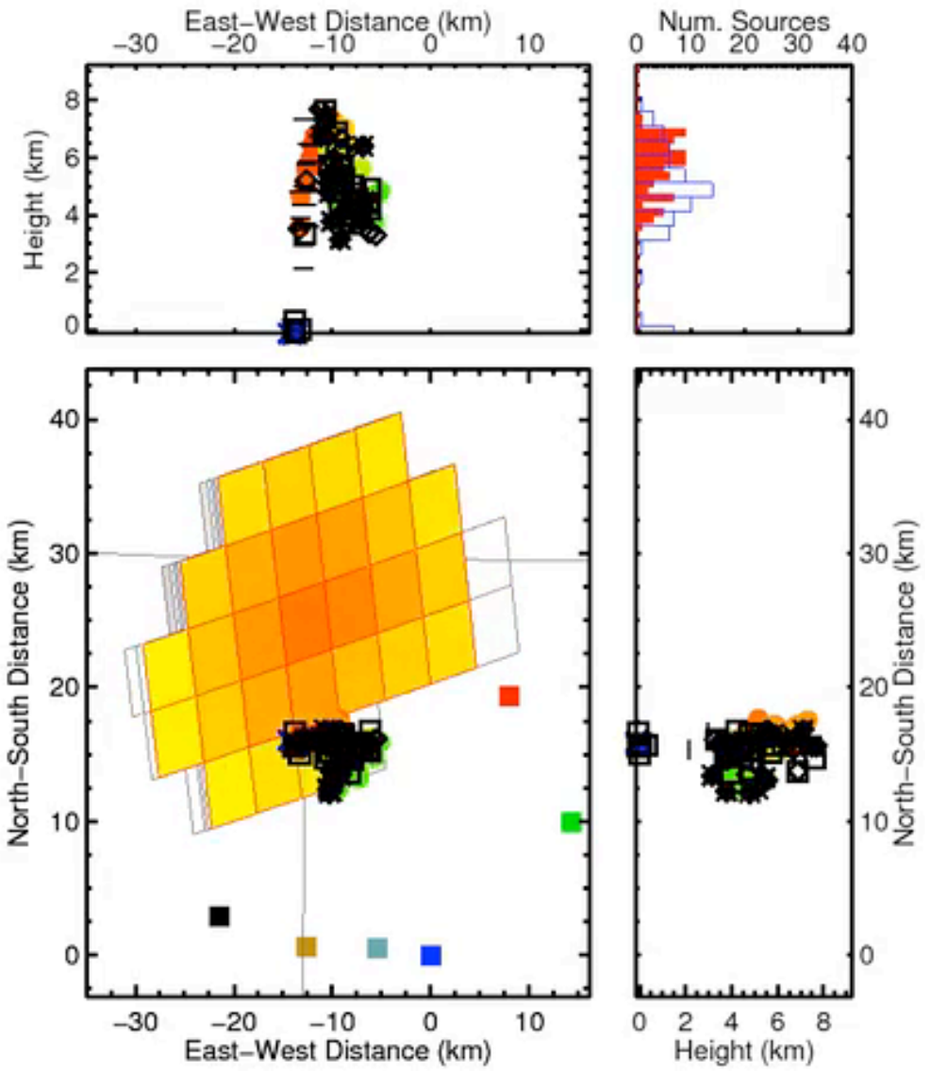


Madison County towers get struck 200x a year!

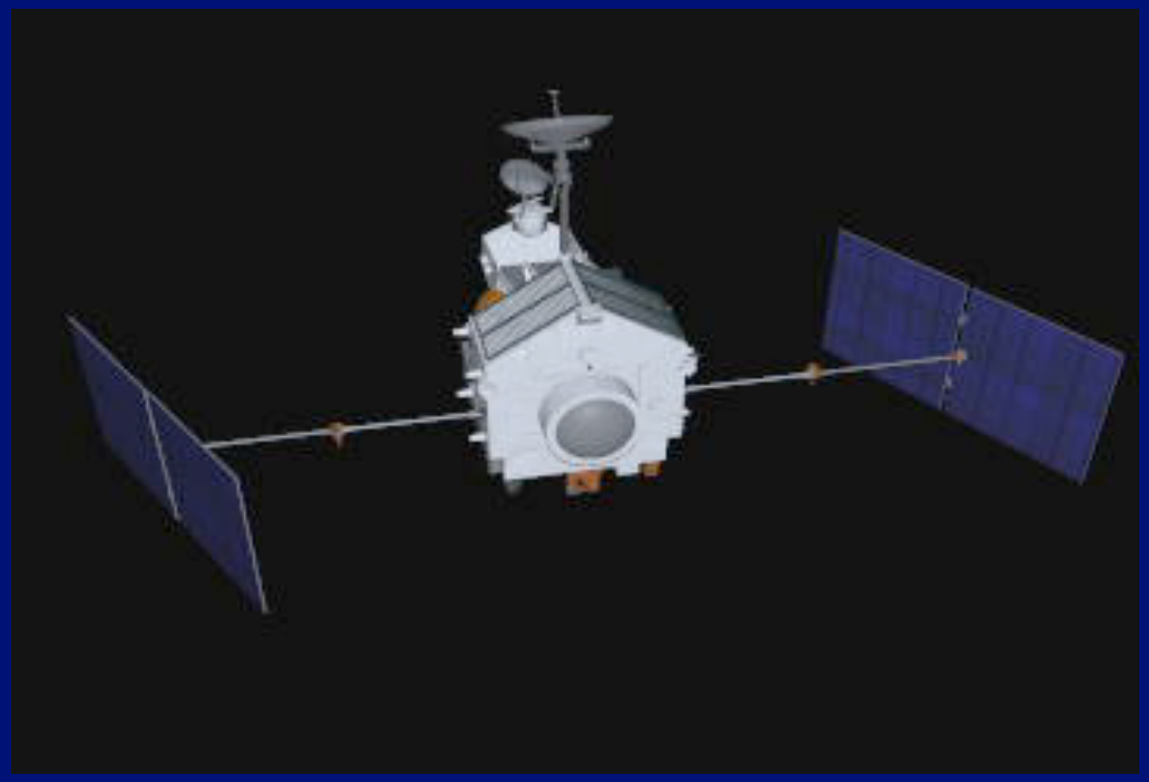
OK, so how else can we measure lightning?

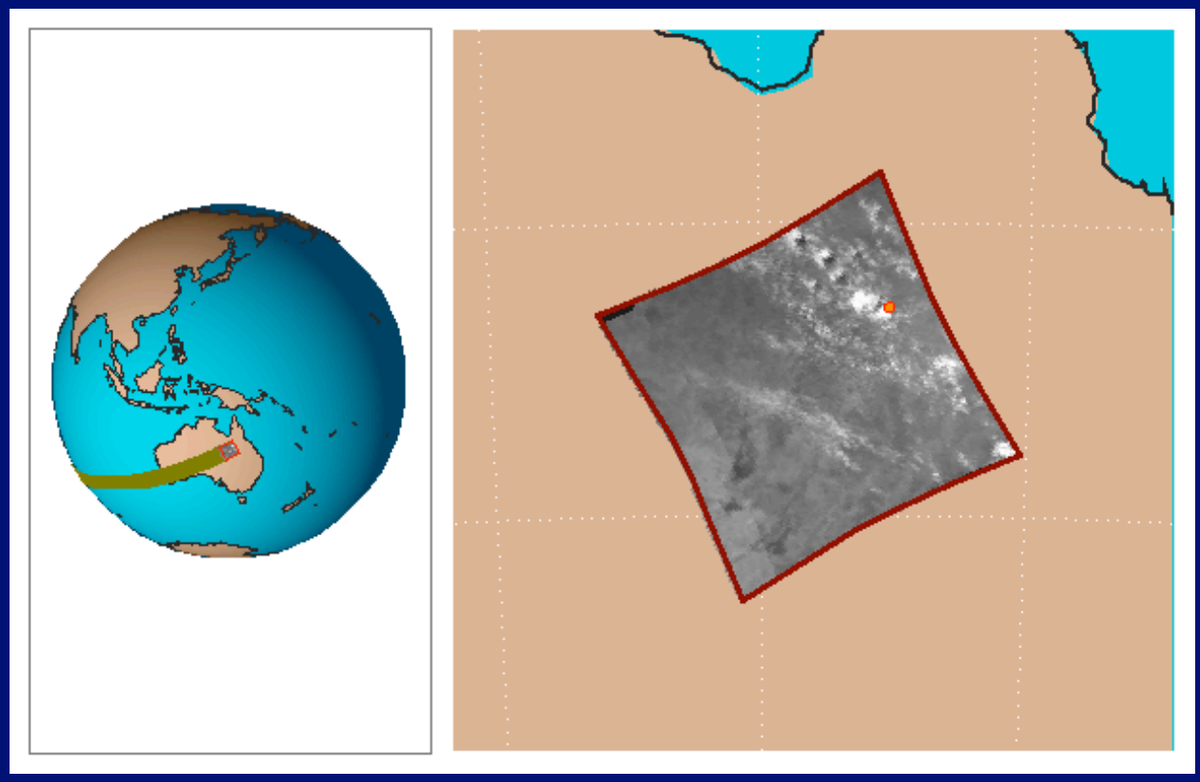
2010/10/25 04:25:58





Base time:	15958.437142
Stop time:	15958.797142
Time Elapsed:	0.360000





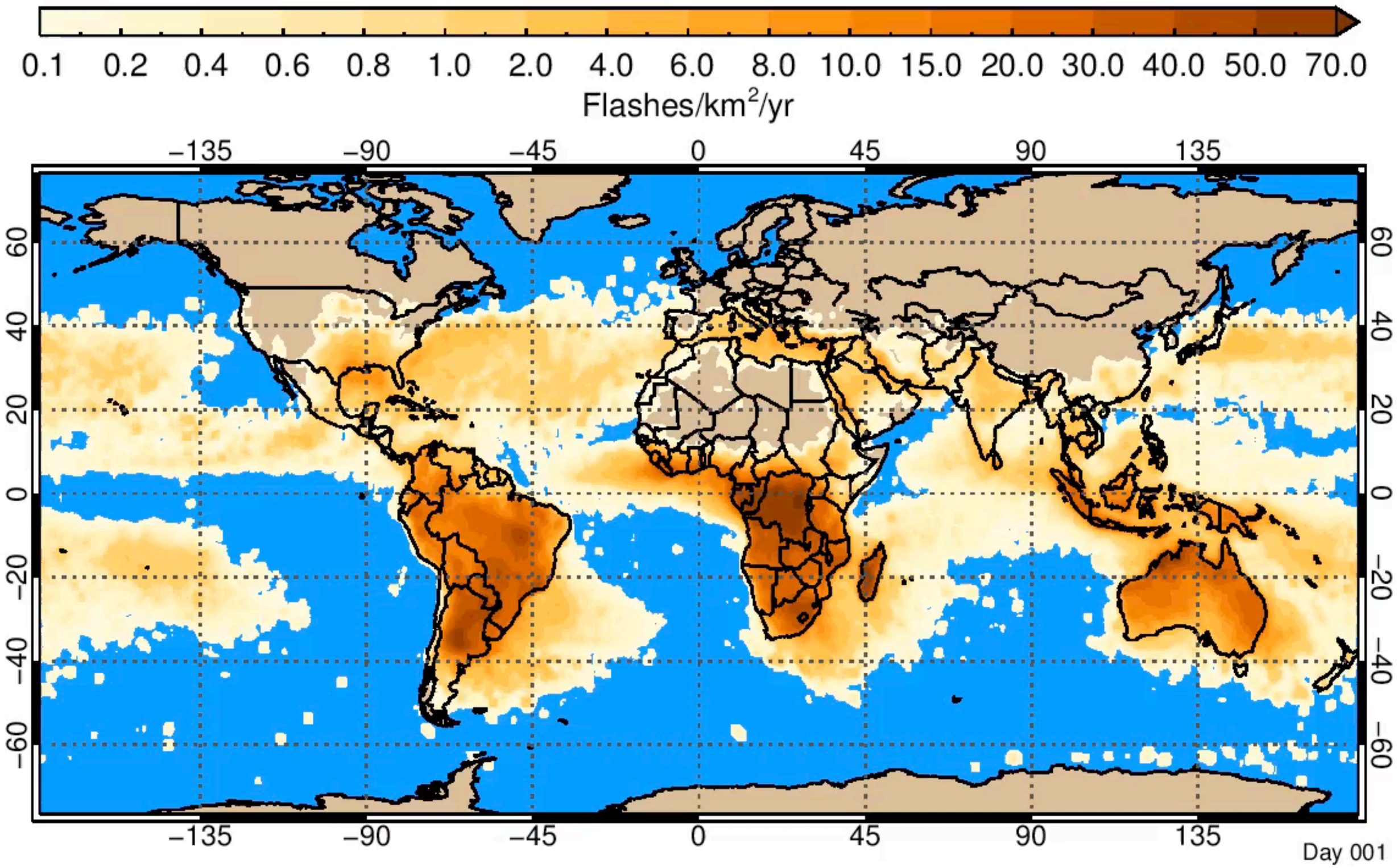
Researchers in Huntsville have built an instrument to “look” at lightning from space

LIS is an **optical *event* detector**

These events can be classified into “groups” and “flashes.”

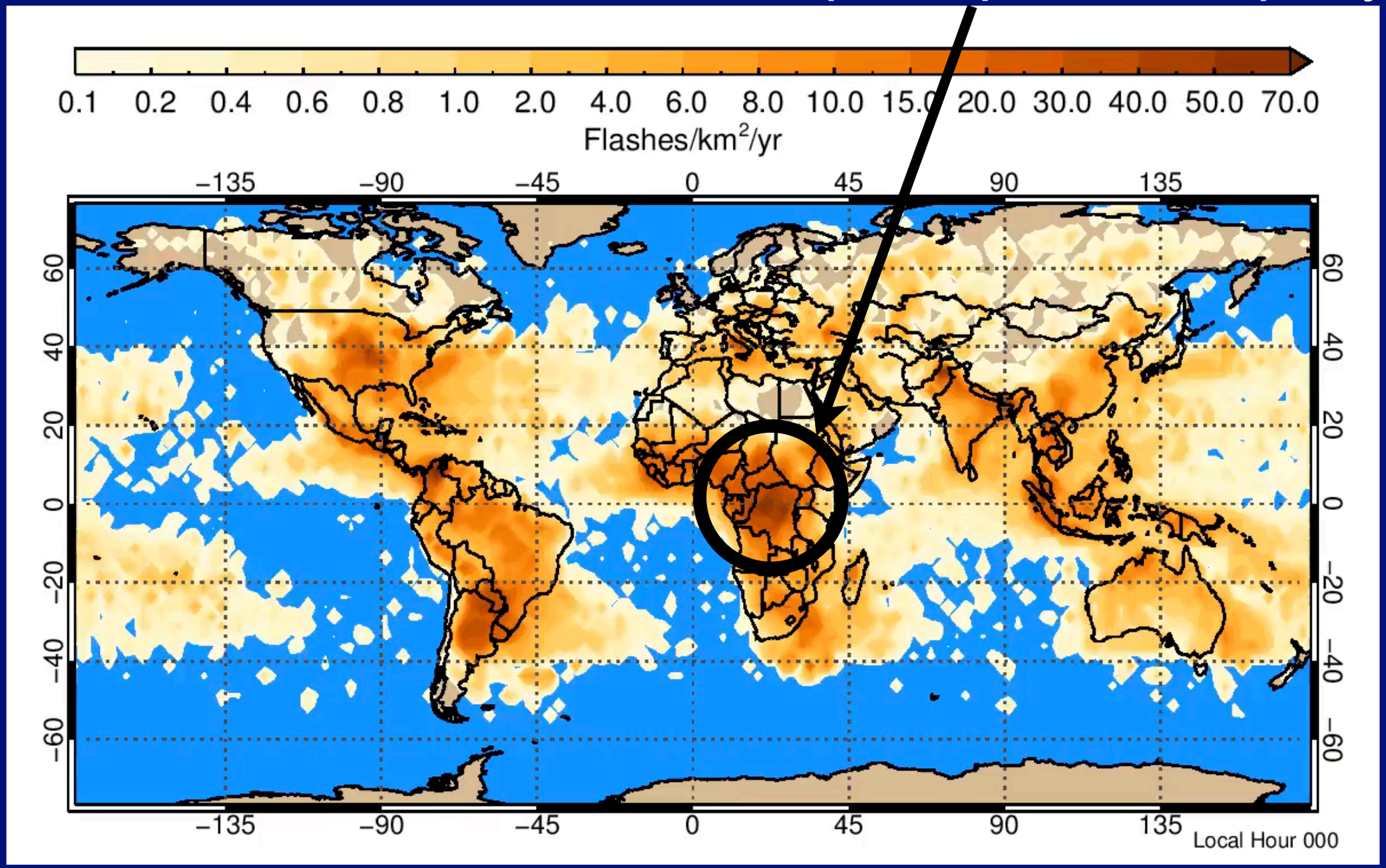
LIS - Lightning Imaging Sensor

How does lightning vary seasonally?



How about daily?

over 250 flashes per square mile per year!



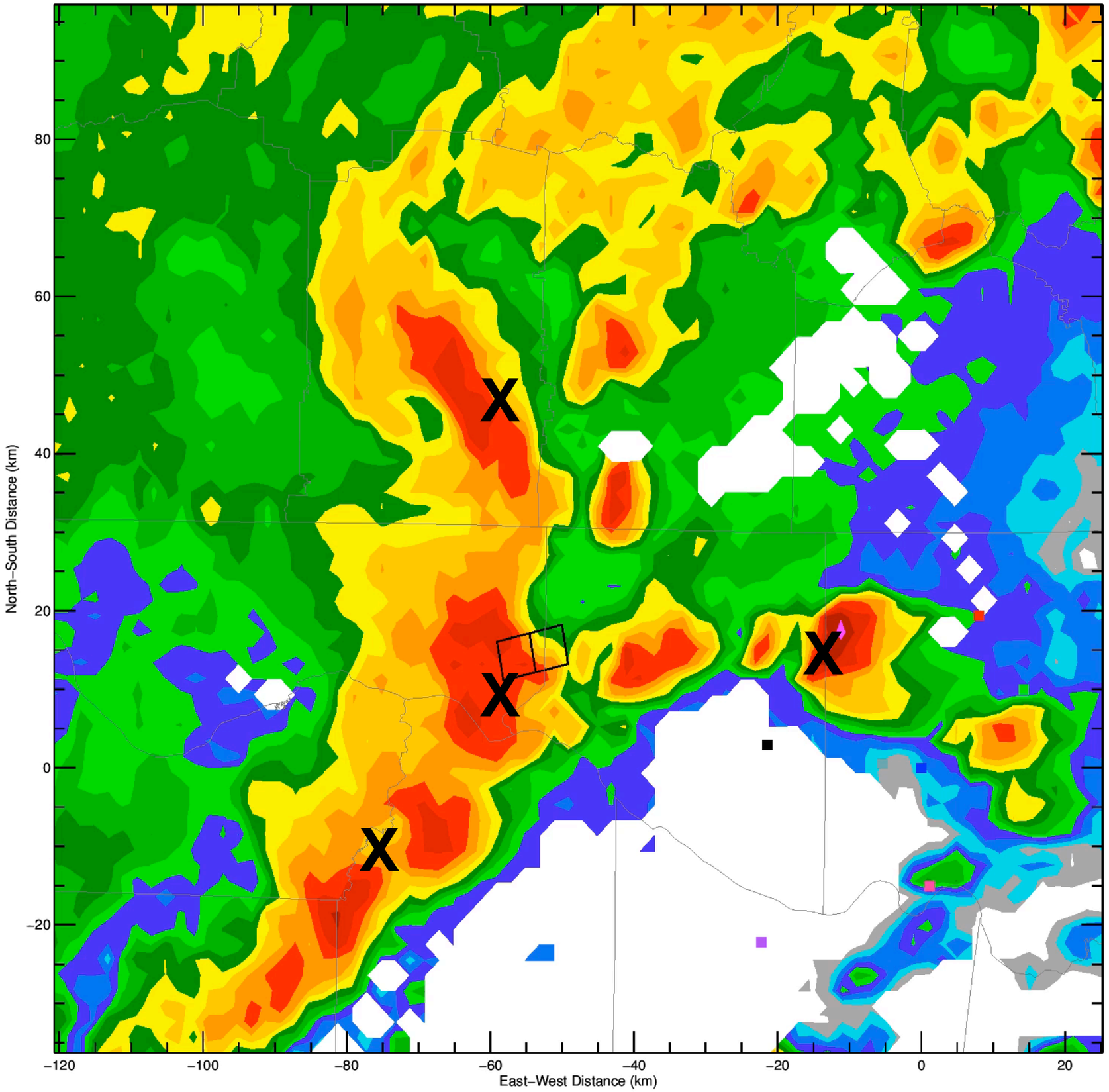
The lightning “heartbeat” of the Earth

on average, there about 45 flashes occurring worldwide per second

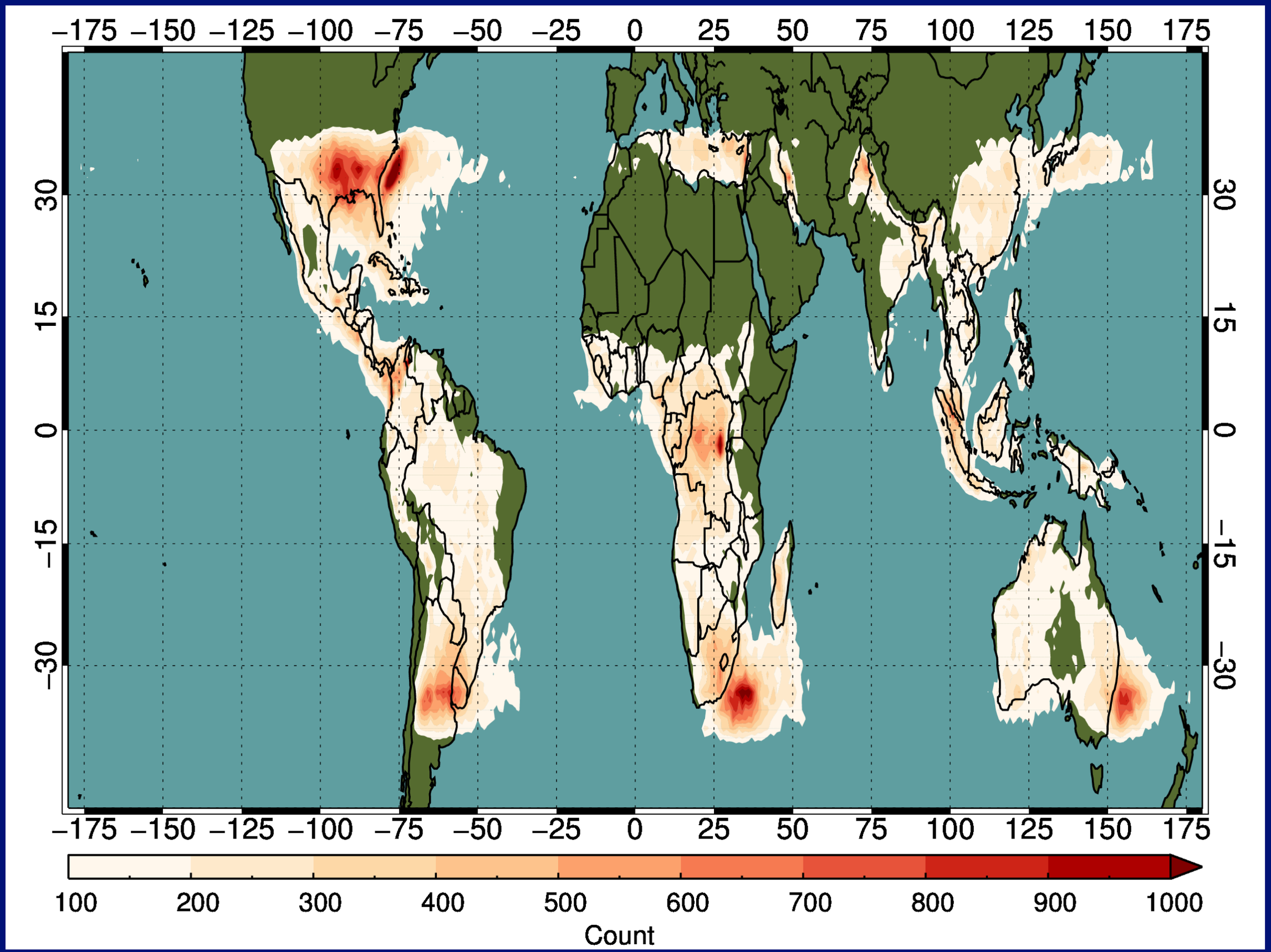
Currently we're working on the Geostationary Lightning Mapper (GLM)

and an instrument for the International Space Station!

But, what can optical measurements of lightning tell me?



About 0.5 seconds of lightning!



11% of all flashes have continuing current worldwide

What is a lightning “flash?” Are there different types of lightning?

Does lightning go up or down?

What are the different ways we can measure **light**ning?

And we're working on a system to be installed in Panama

We have sensors in Huntsville we use to investigate lightning energetics

Why, yes,
that is an arrow
shot out of
a balloon..
(at 2000 fps)

Total time: 25 msec!

80 msec later, still going...

Frame 01062