

# Correlated High Speed Video, Medium Range E-Field, and B-field observations of Sprites

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# (Some) Prior Work

- Sprites associated with large +CG flashes  
(*Boccippio et al., Science 1995*)
- Brightness proportional to current, driven by field  
(*Pasko, et al., JGR 1997*)
- Sprites delayed up to 120 ms from parent flash  
(*Li, Cummer, et al., JGR 2008*)
- VLF (B-field) measurements see effect from sprite itself in ~10% of cases  
(*Cummer, Inan et al., GRL 1998*)

# Goals

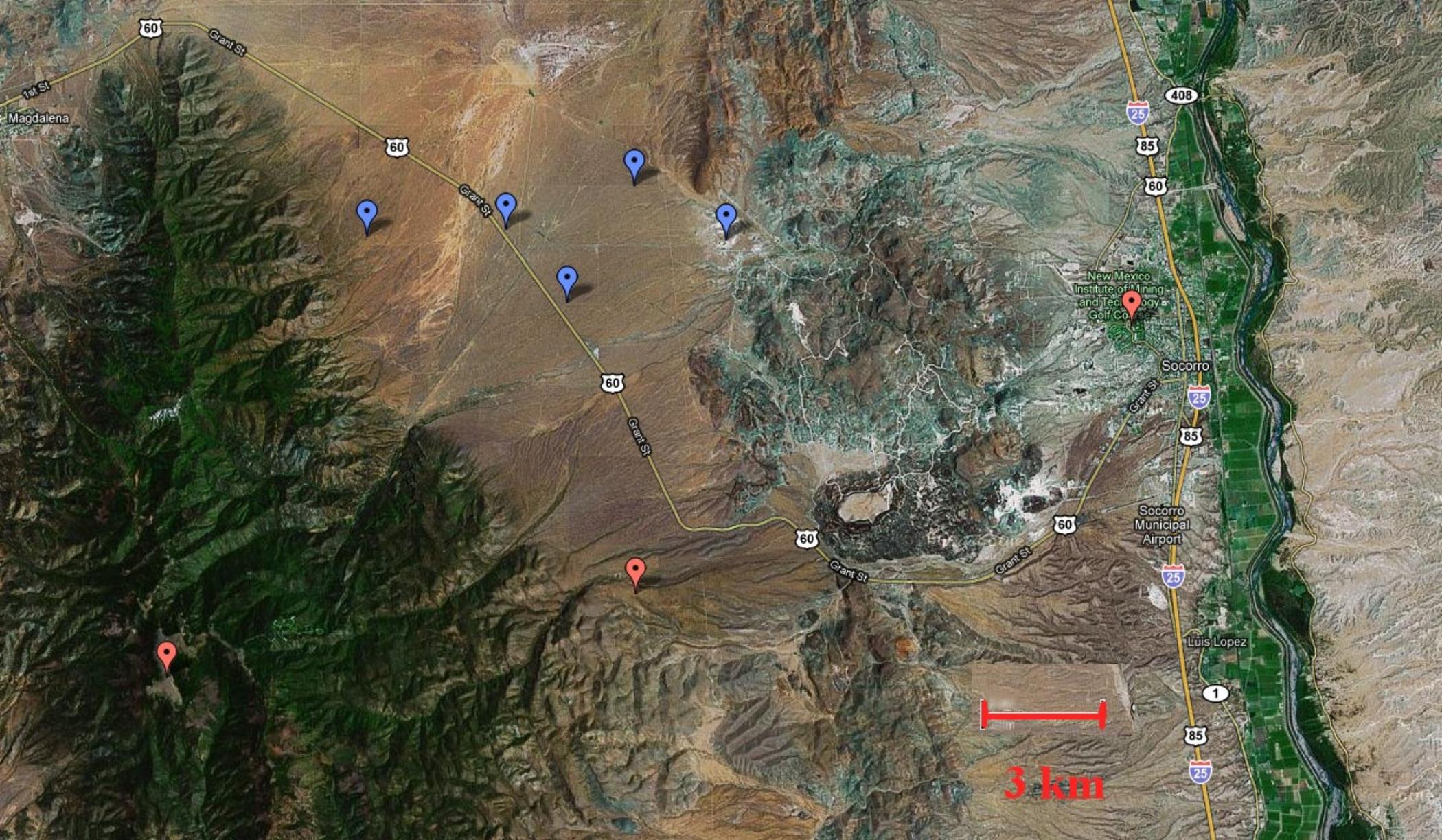
Measure time between lightning flash and sprite initiation.

Correlate E-field and B-field.

Look for current signature of sprite in Electric field records.

Look for electrostatic signature of sprite.

# Langmuir Electric field Array



Network of eight field-change stations

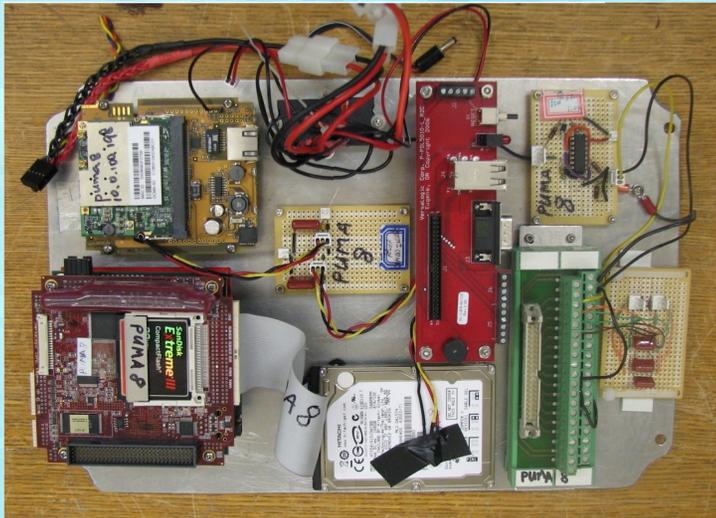
# Langmuir Electric field Array

GPS disciplined timing

Digitize with three different sensitivities.

Sample period is 20 microsec.

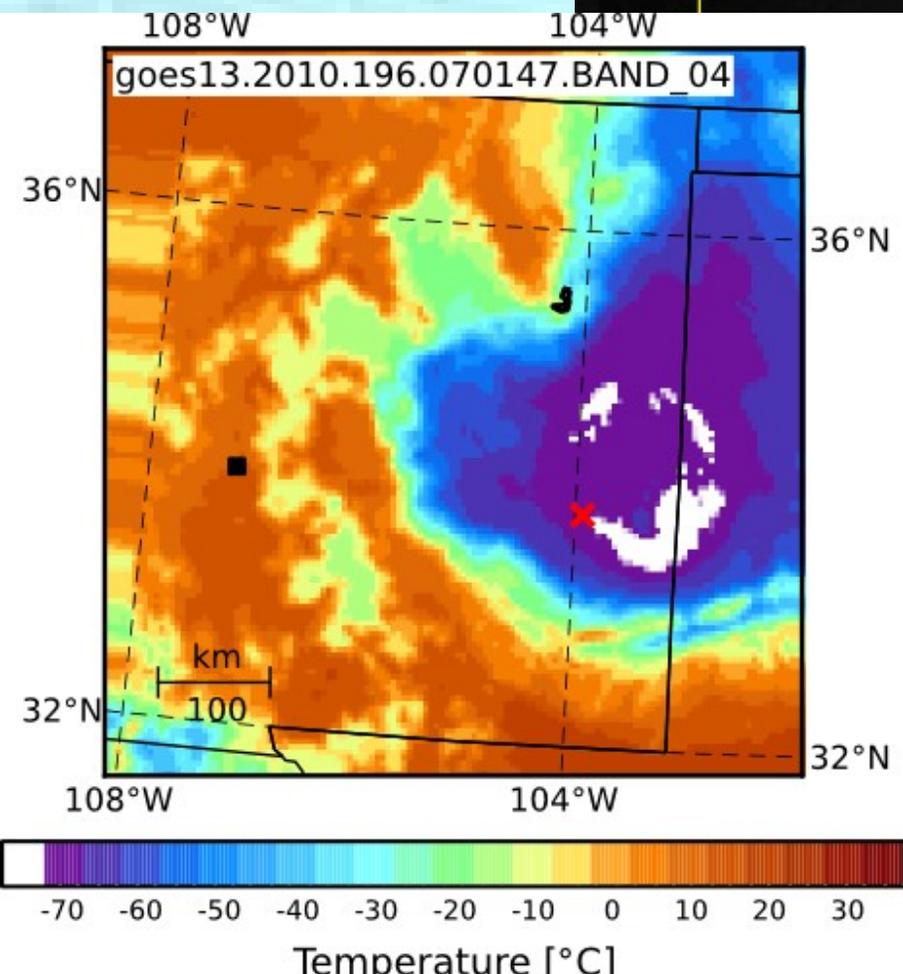
$10 \text{ mV/m} < E < 400 \text{ kV/m}$



Sprite "A"

Closest ...

7/15/10 7:06:09.808 UT

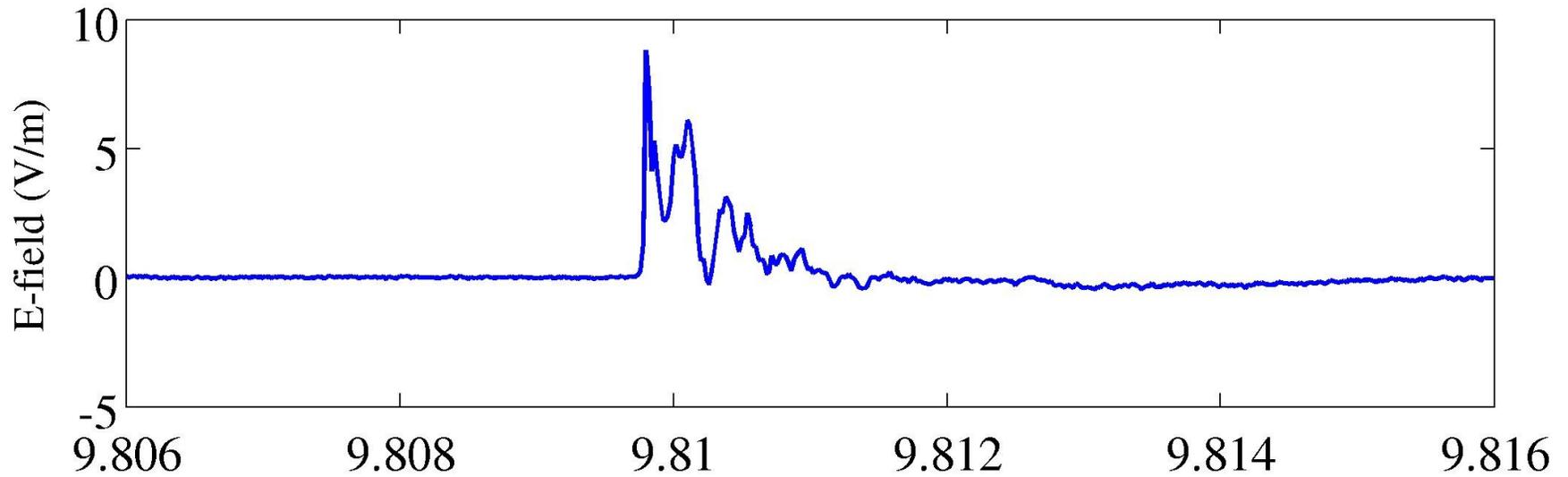


$$D_{\text{LANGMUIR}} = 275 \text{ km}$$

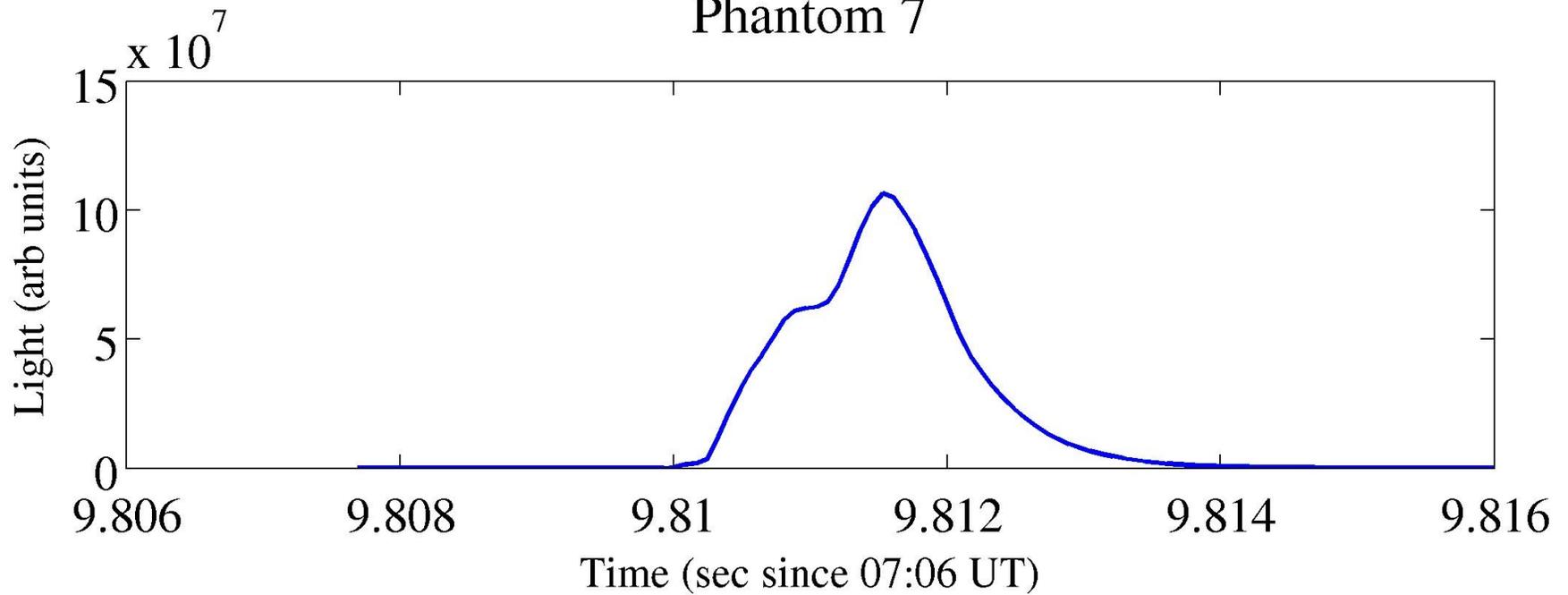
$$D_{\text{DUKE}} = 2600 \text{ km}$$

# Sprite "A"

lefa2-20100715-S



Phantom 7



# Time Delays

from first Field change to first light

## Parent Flash Information

## Time Delay (ms)

7/13/10

6:03:04.263      29.36 -109.65      221.0 kA      < **0.5**

7/15/10

5:22:01.710      34.34 -102.21      68.0 kA      **5.3**

**B** 5:27:09.694      **34.24 -102.10**      **80.0 kA**      **1.5**

5:32:57.564      34.36 -102.31      33.0 kA      **1.8**

5:45:14.489      34.16 -102.16      8.0 kA      **5.0**

5:55:54.807      34.38 -102.08      51.0 kA      **3.3**

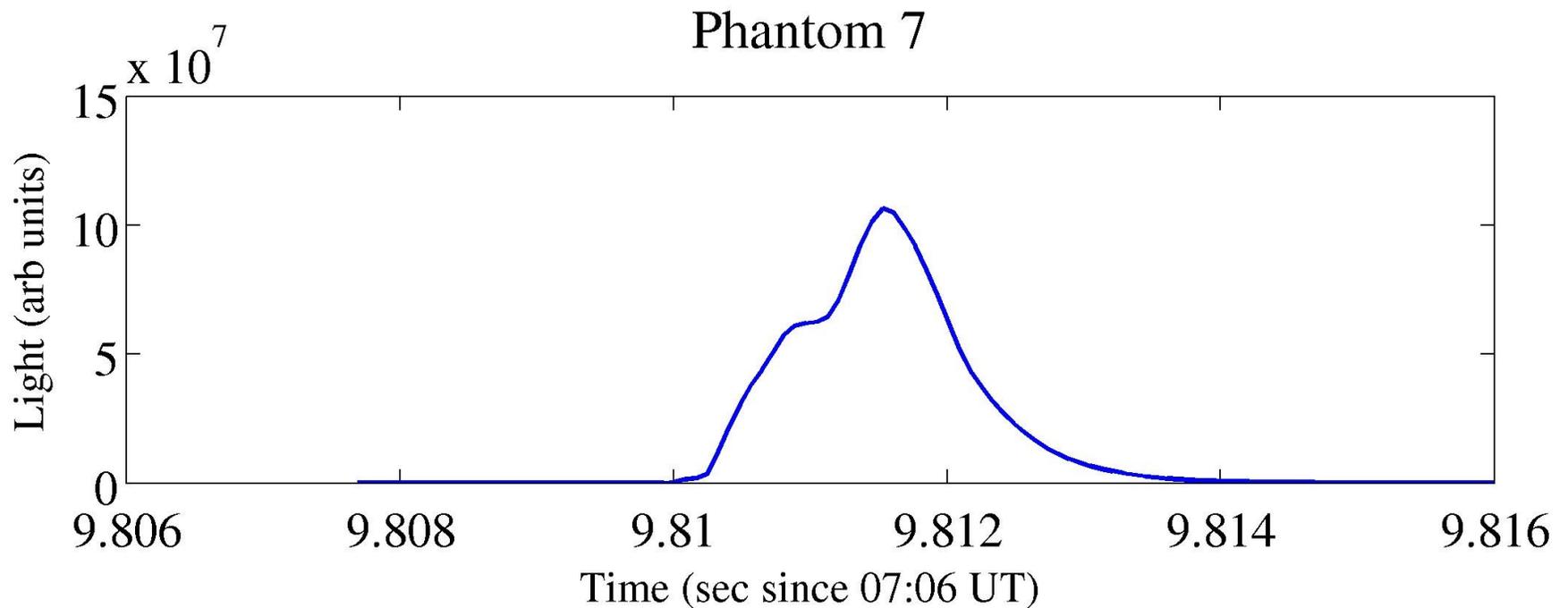
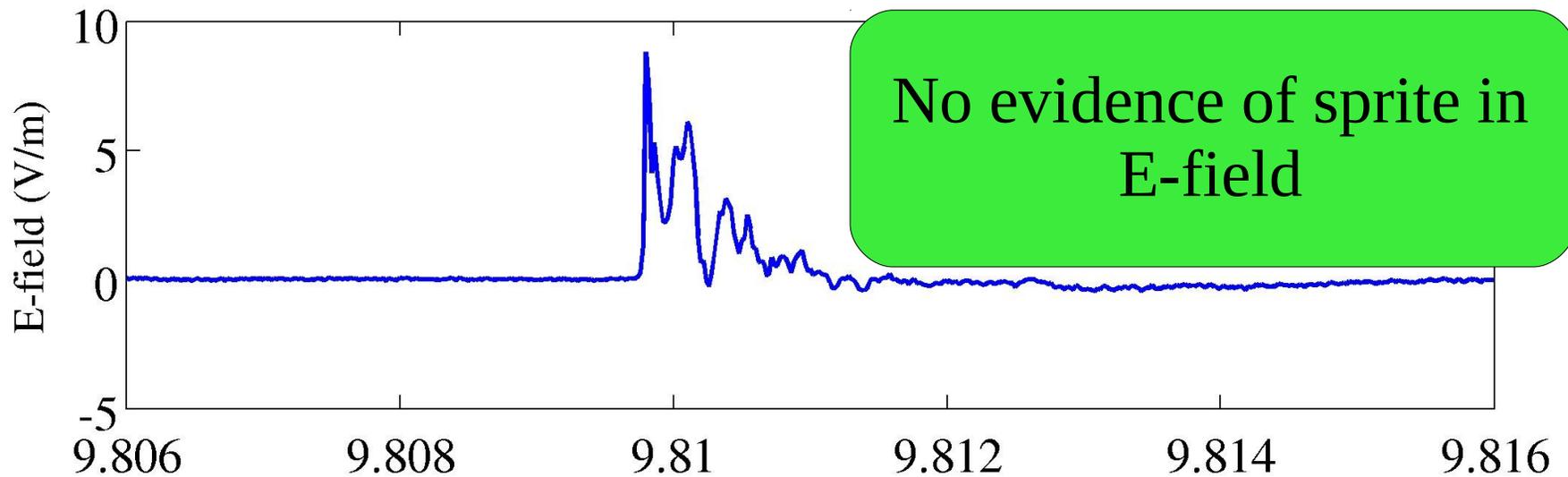
6:41:36.081      34.02 -103.40      78.0 kA      **1.5**

7:00:31.844      34.00 -103.32      53.0 kA      **1.5**

**A** 7:06:09.808      **33.80 -103.93**      **111.0 kA**      **0.5**

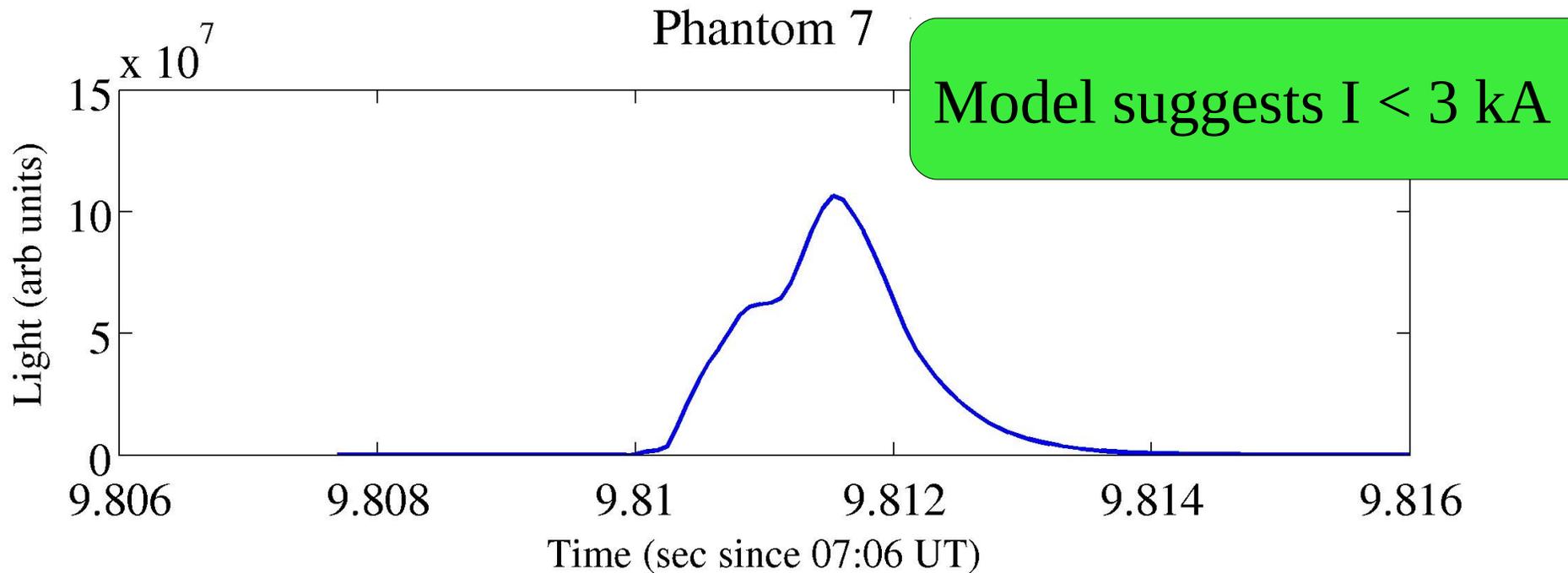
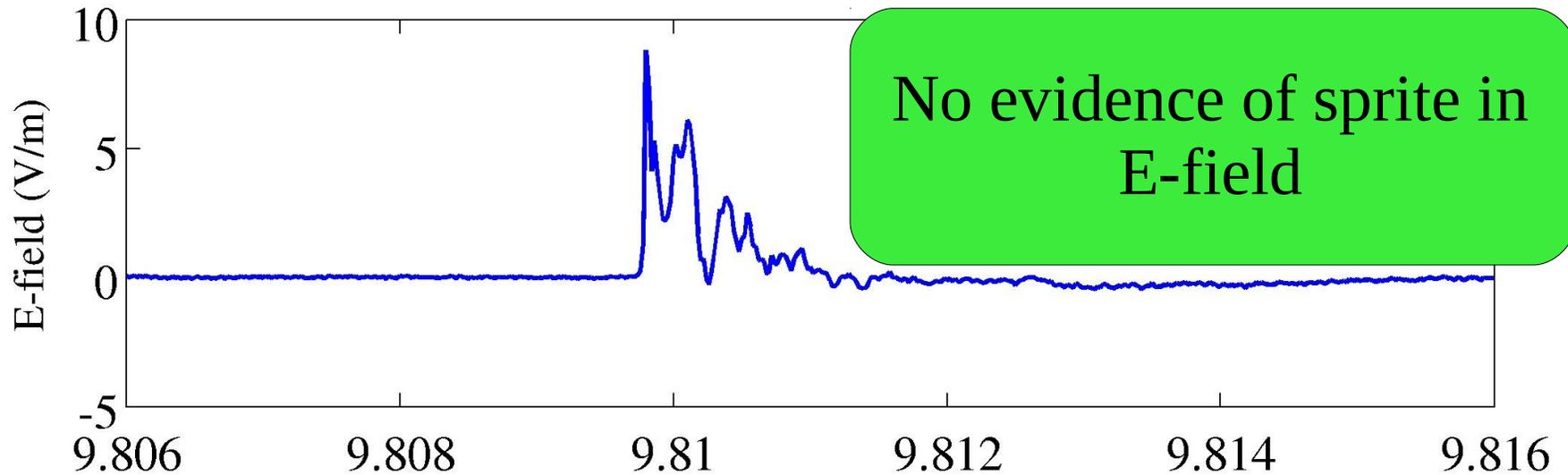
# Sprite "A"

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# Sprite "A"

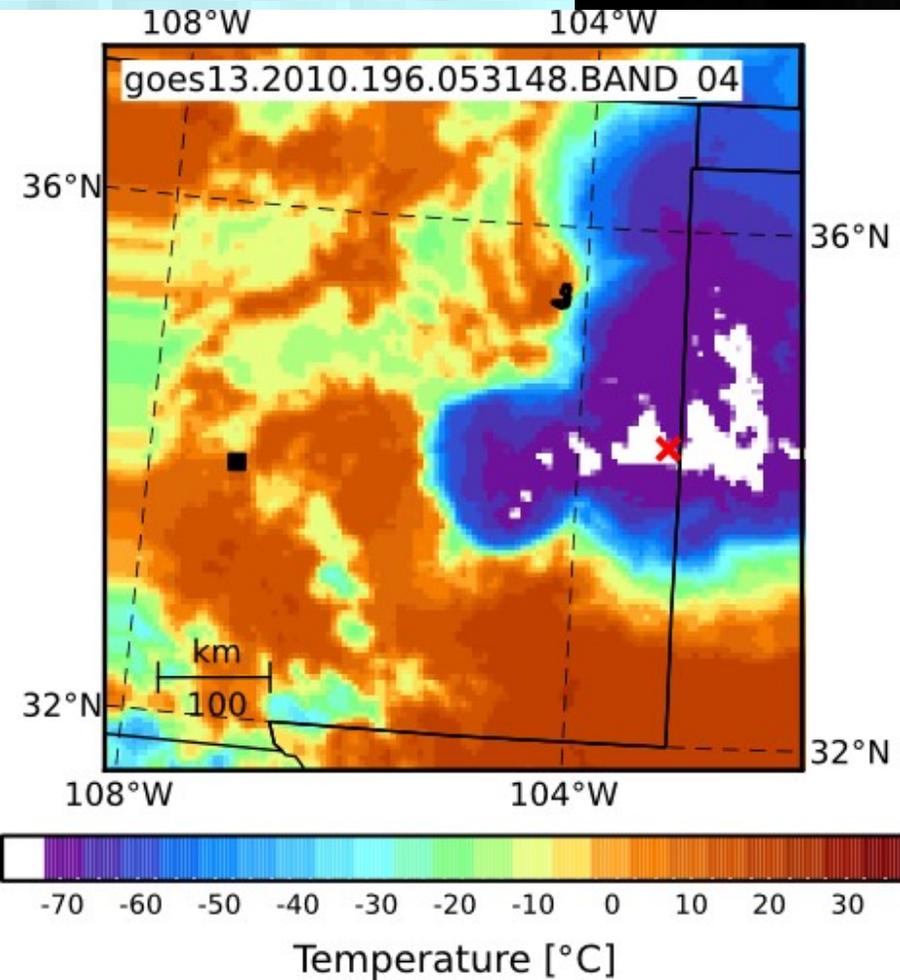
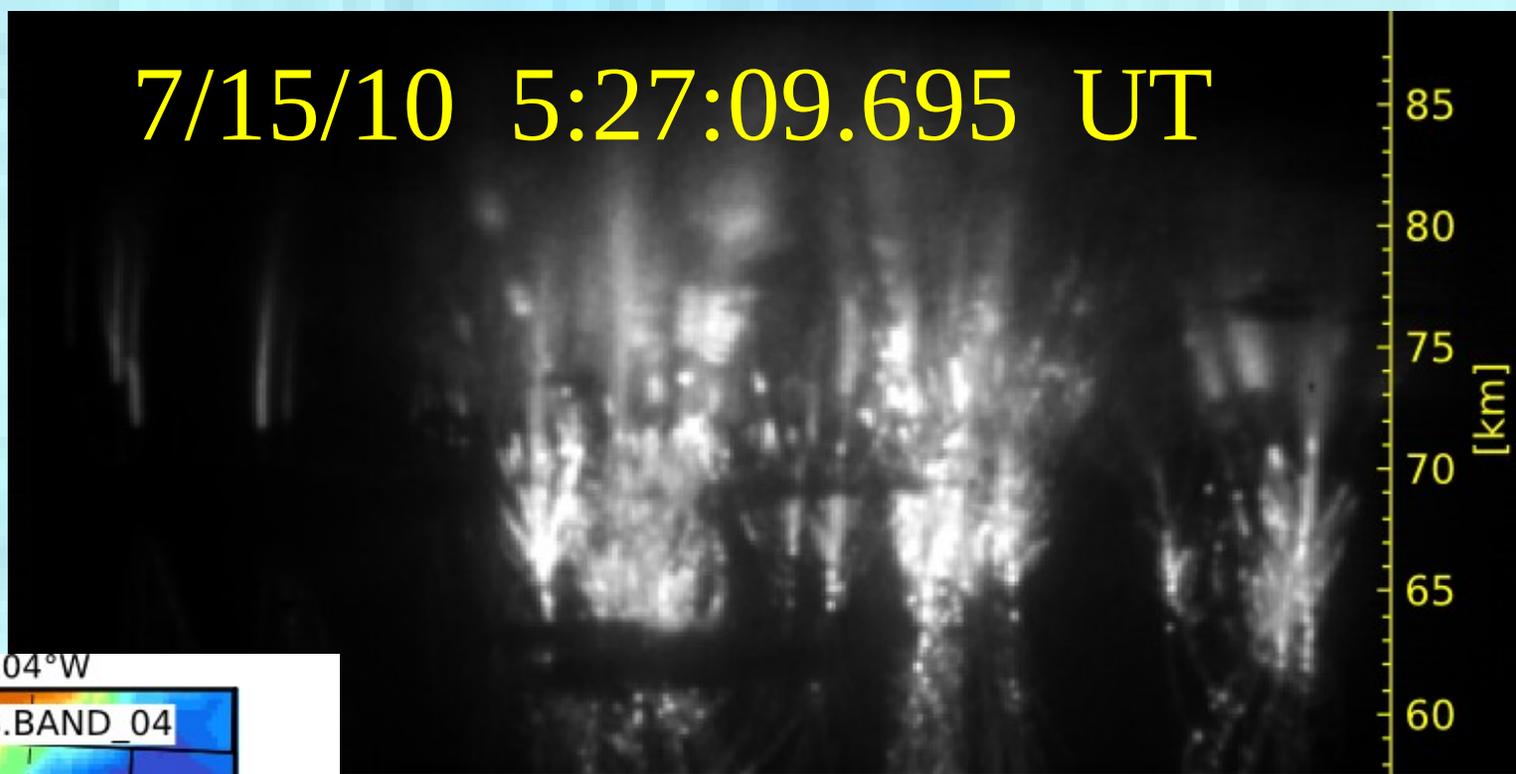
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7/15/10 5:27:09.695 UT

Sprite "B"

D=470 km



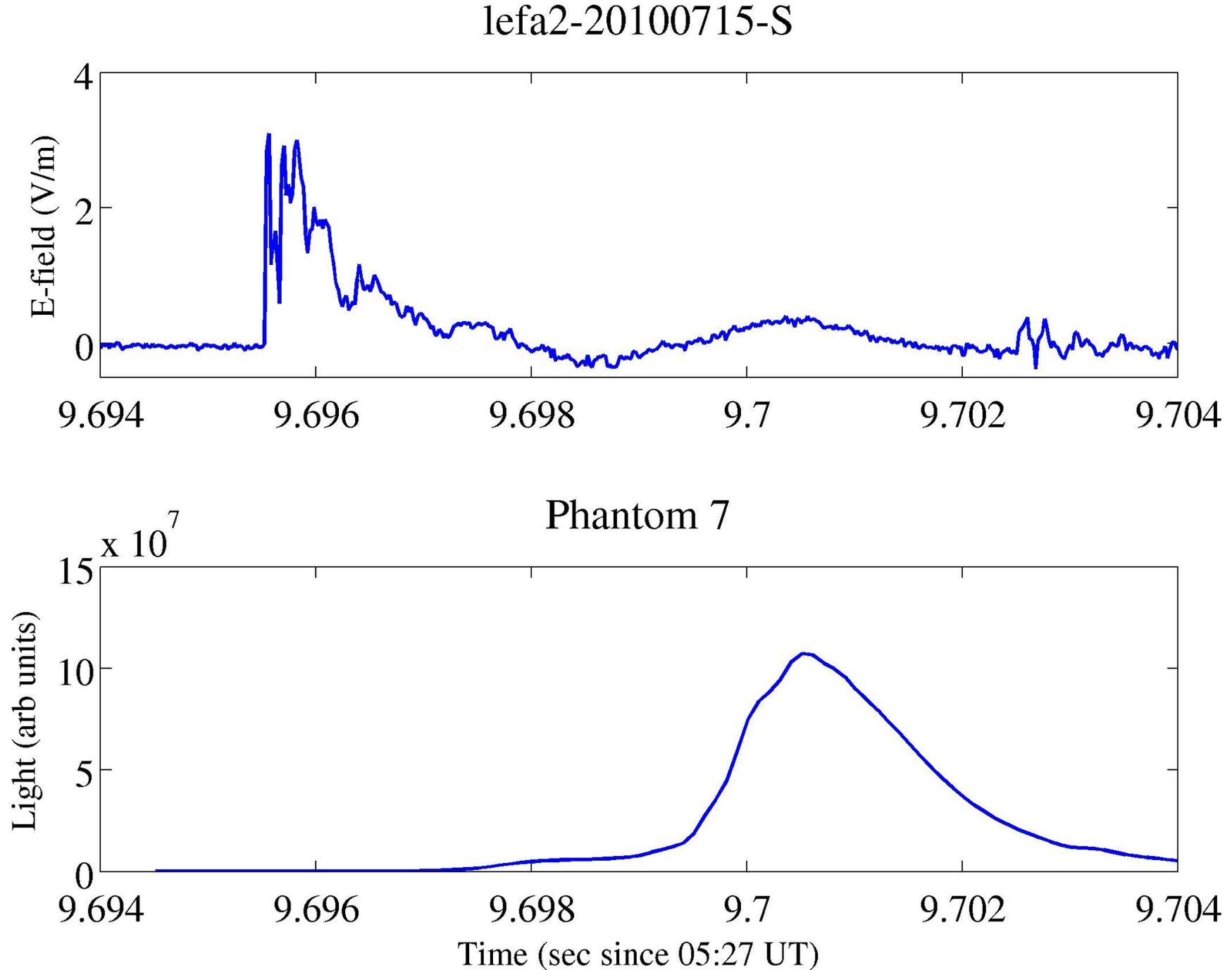
$$v = 10^7 \text{ m/s}$$

$$I_{\text{PEAK}} = 30 \text{ kA}$$

$$Q = 45 \text{ C}$$

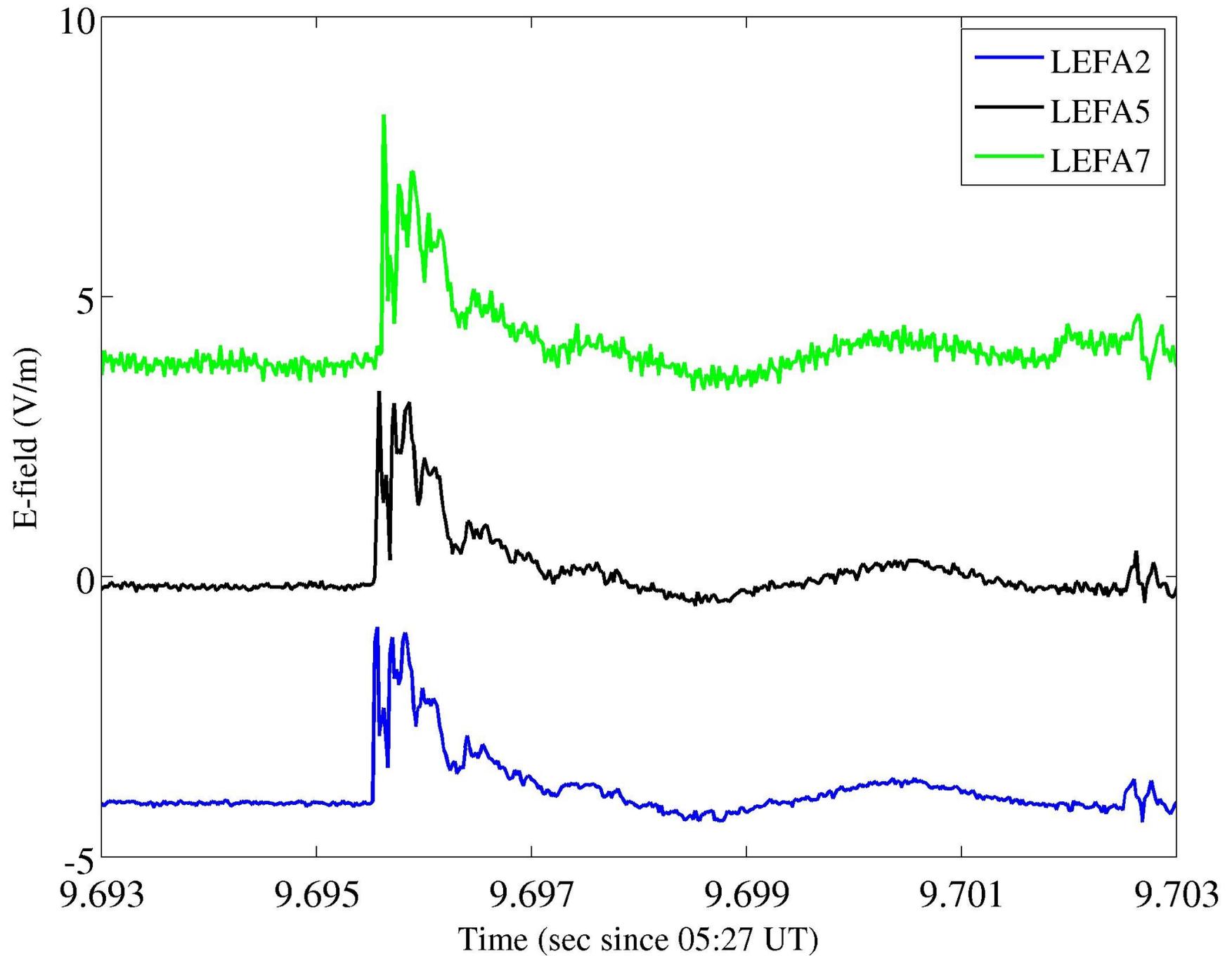
$$M = 650 \text{ C} \cdot \text{km}$$

# Sprite "B": Clear sprite signature in E



# Sprite "B": E-field signature

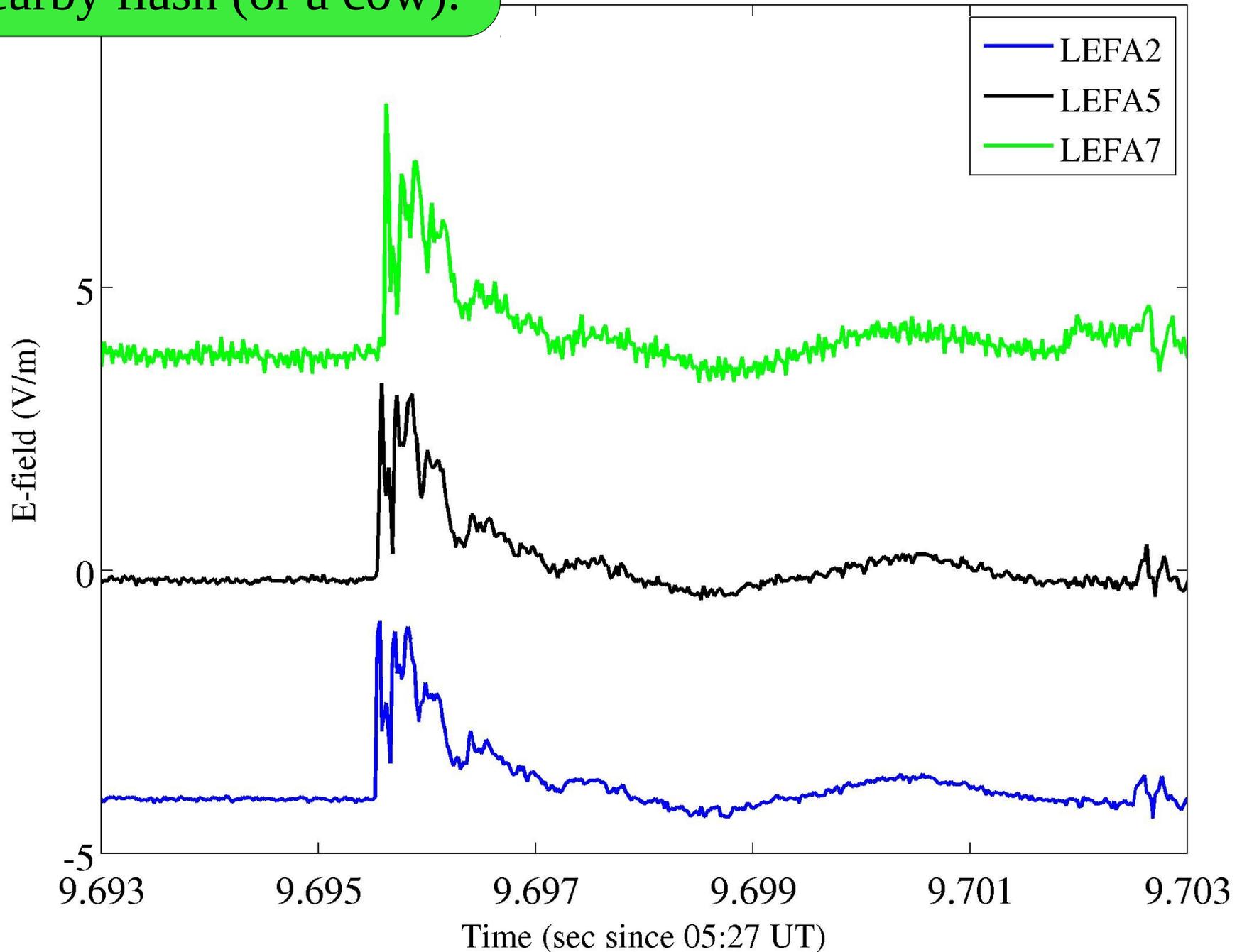
20100715-S



Waveform highly reproducible. Thus not a nearby flash (or a cow).

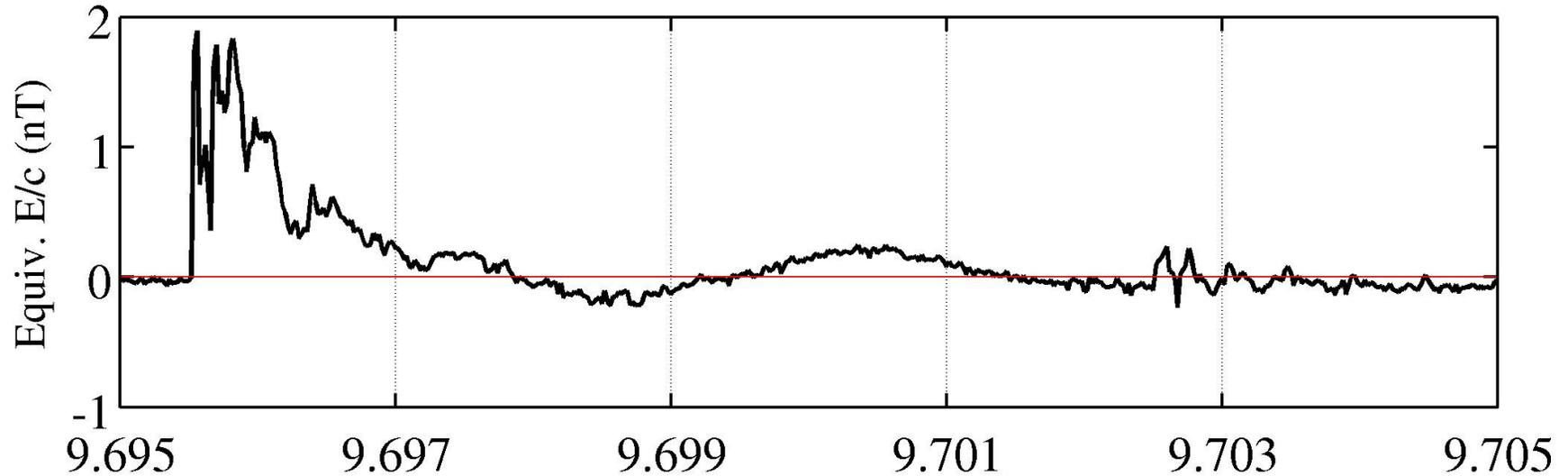
# : E-field signature

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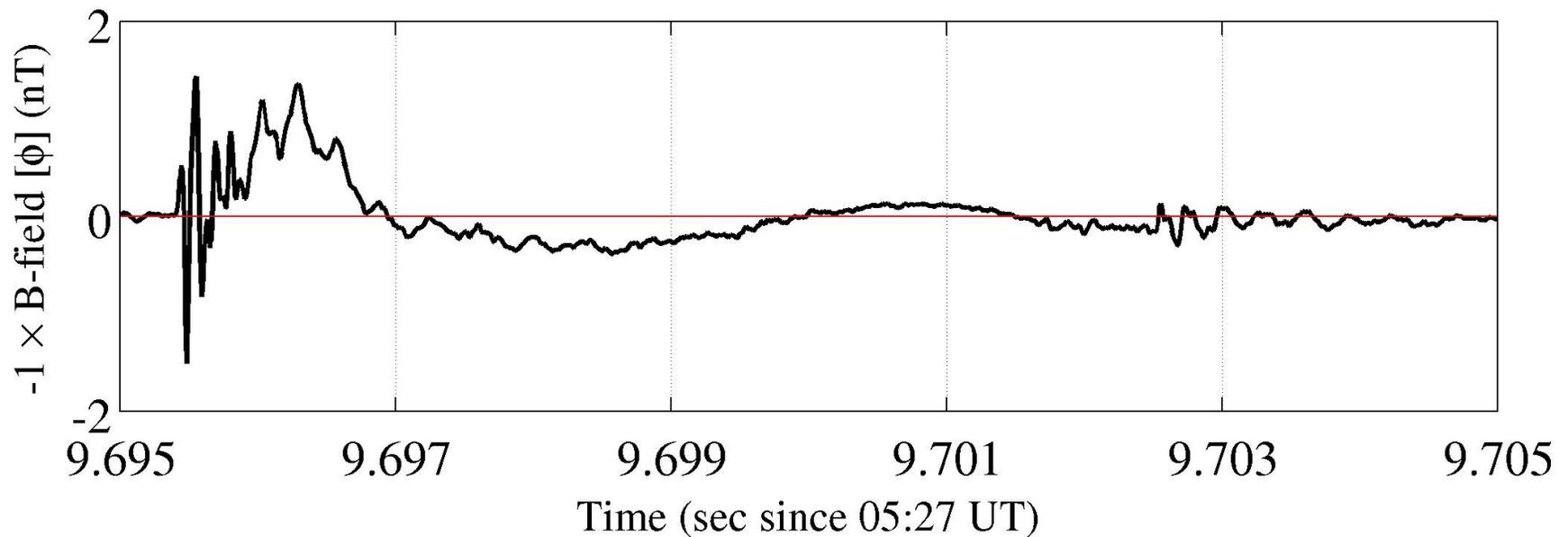


# Sprite "B": EM signature

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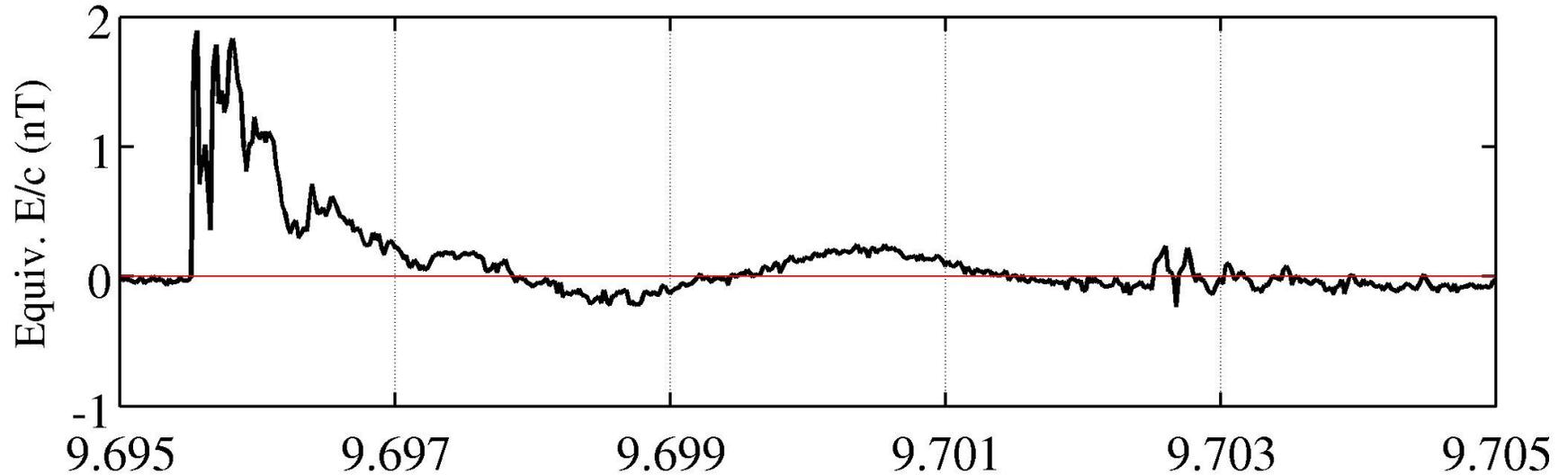


Duke VLF Station

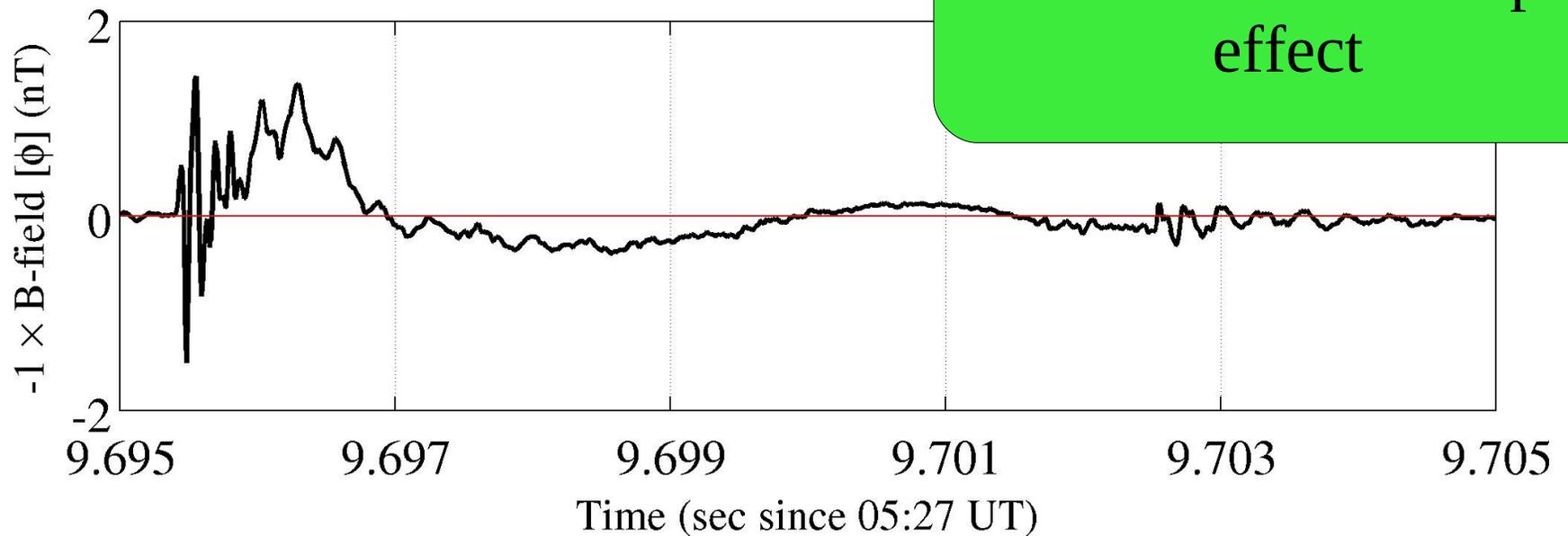


# Sprite "B": EM signature

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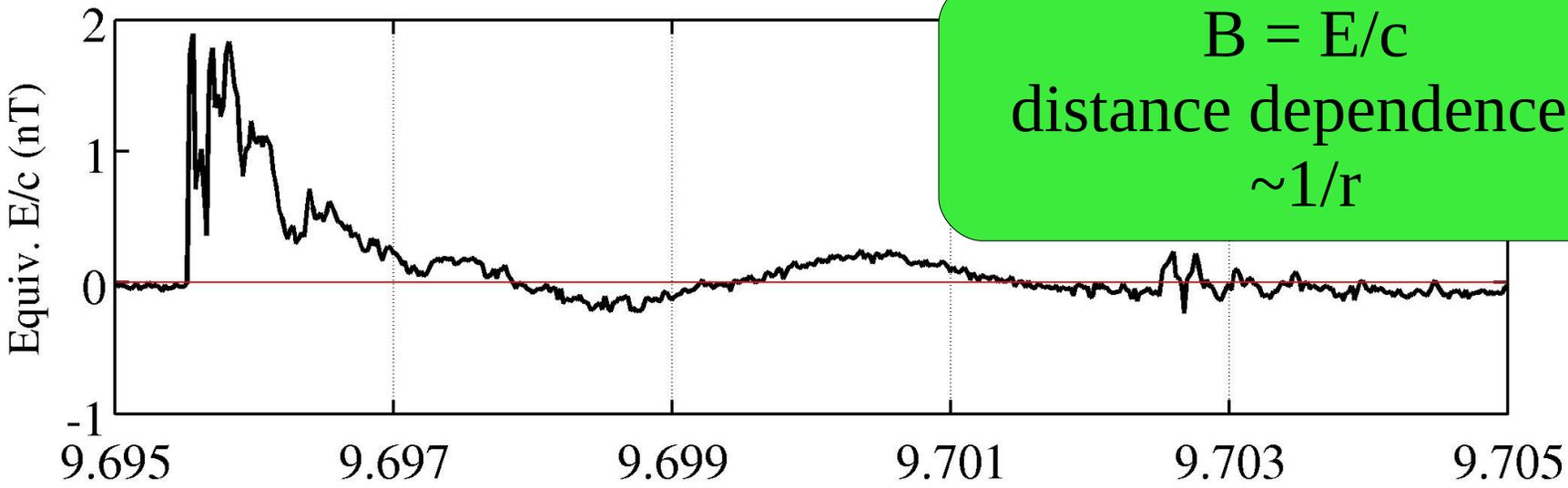


Duke VLF Stat



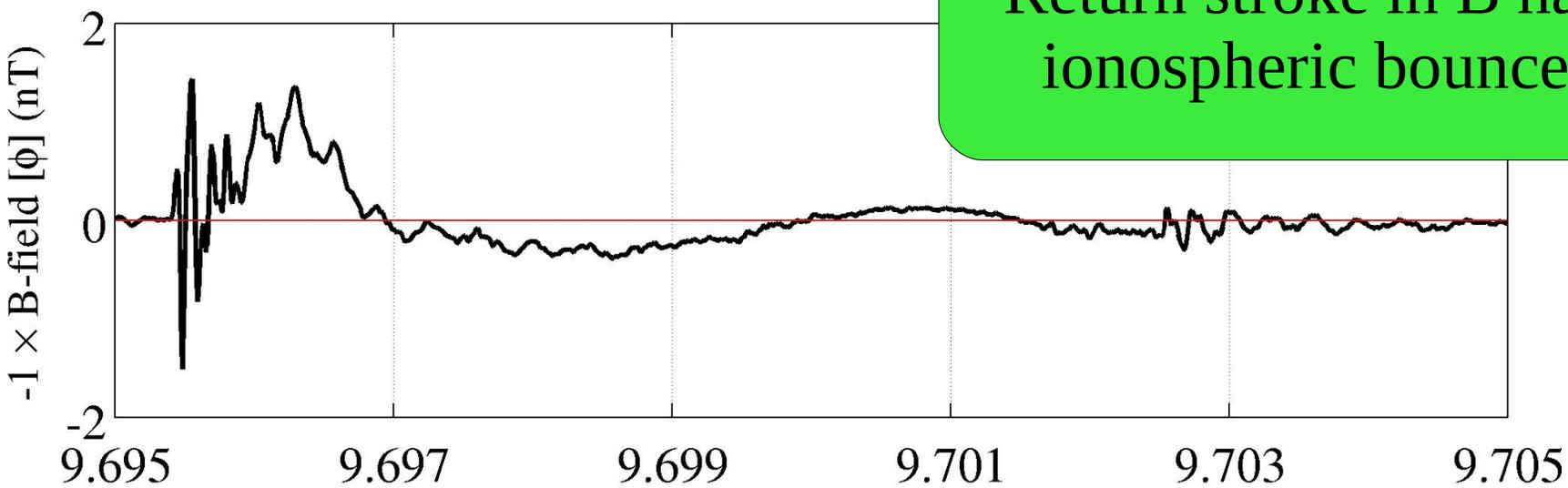
B and E both show sprite effect

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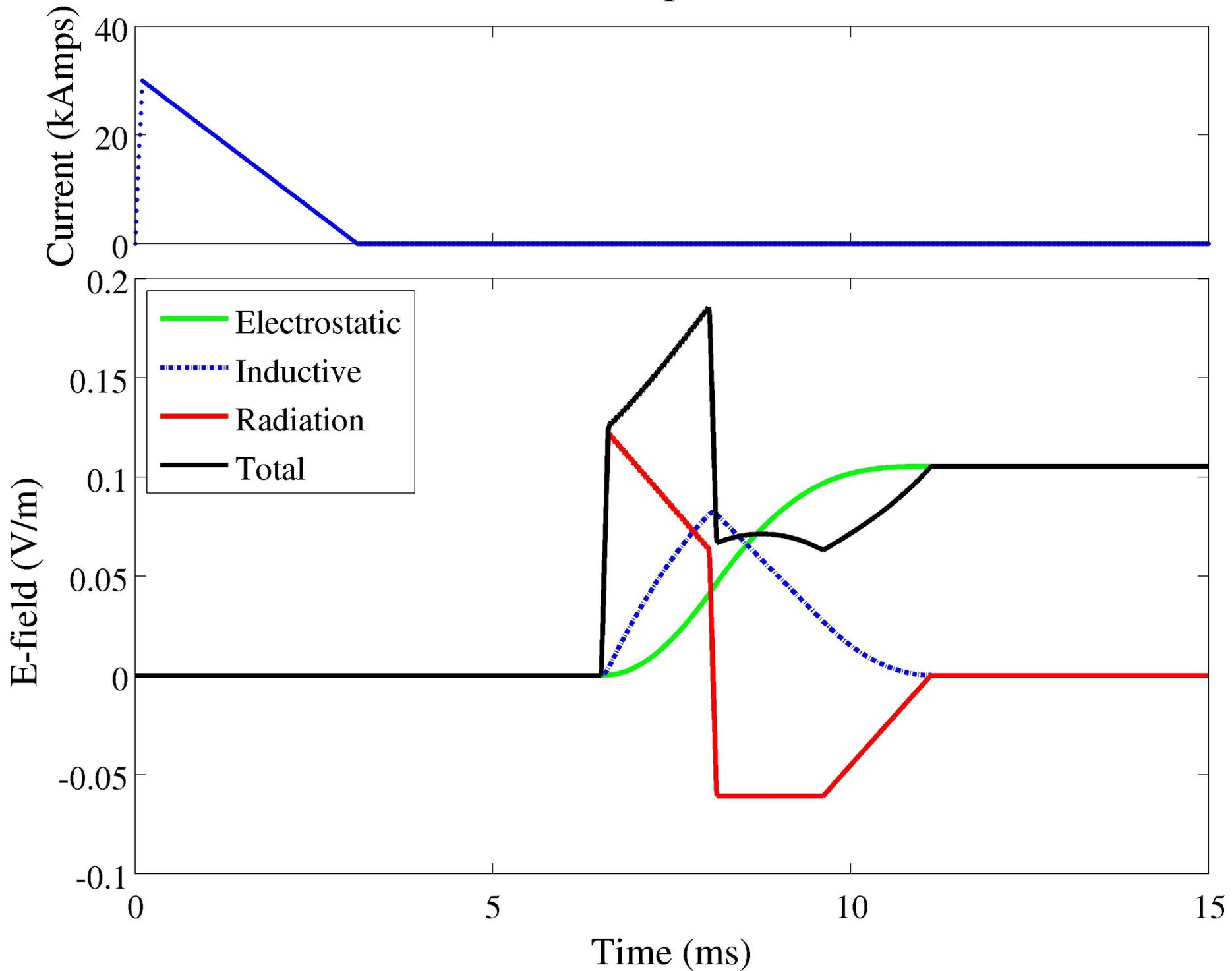
$B = E/c$   
distance dependence  
 $\sim 1/r$

Duke VLF Stat

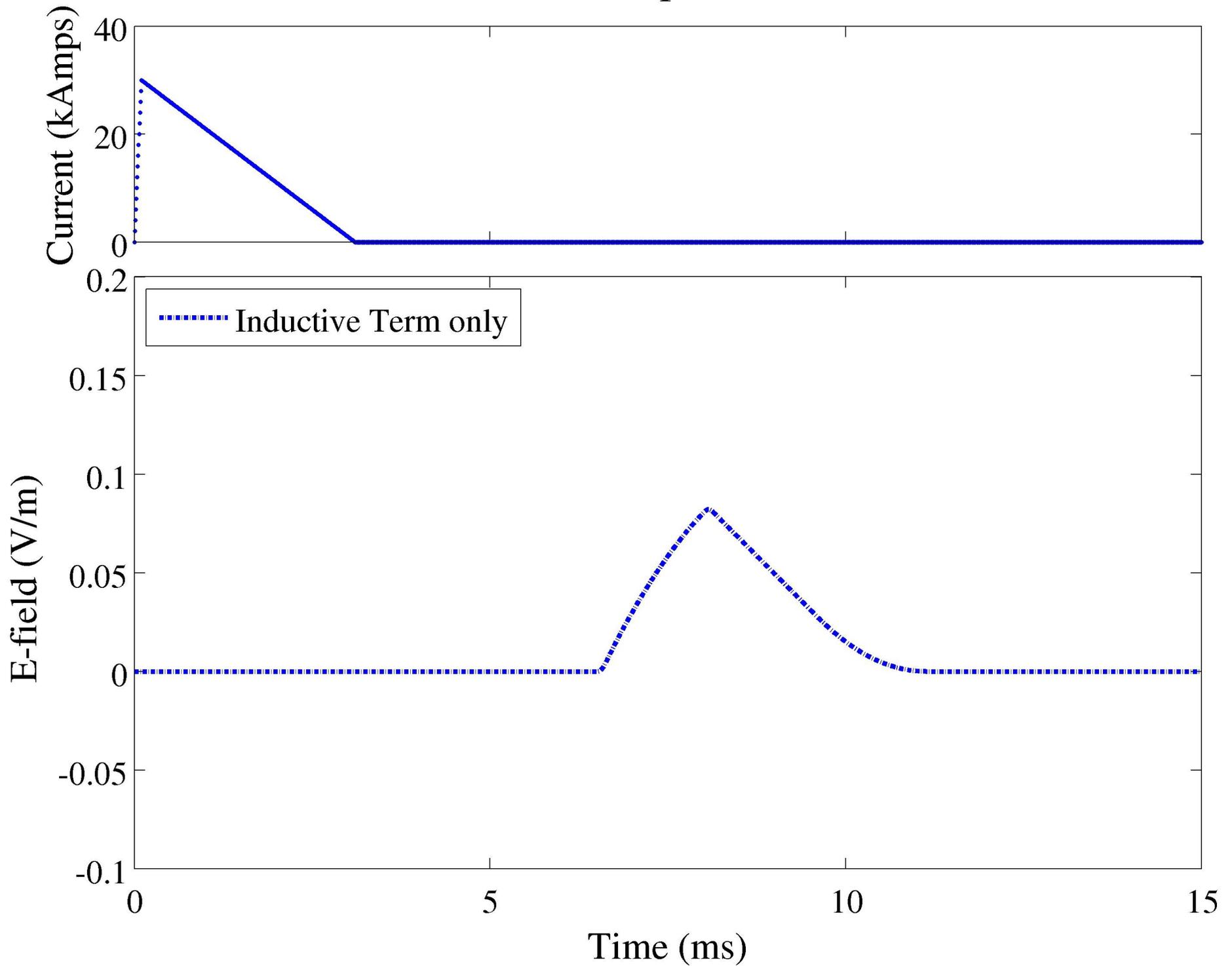


Return stroke in B has  
ionospheric bounce

# E-field terms on vertical Sprite channel, from 470 km



# E-field terms on vertical Sprite channel, from 470 km



# Conclusions

Clear sprite E-field signature in 1 of 9 sprite flashes.

E-field and B-field signatures similar.

E-field effects look proportional to current.

No electrostatic effects observed.

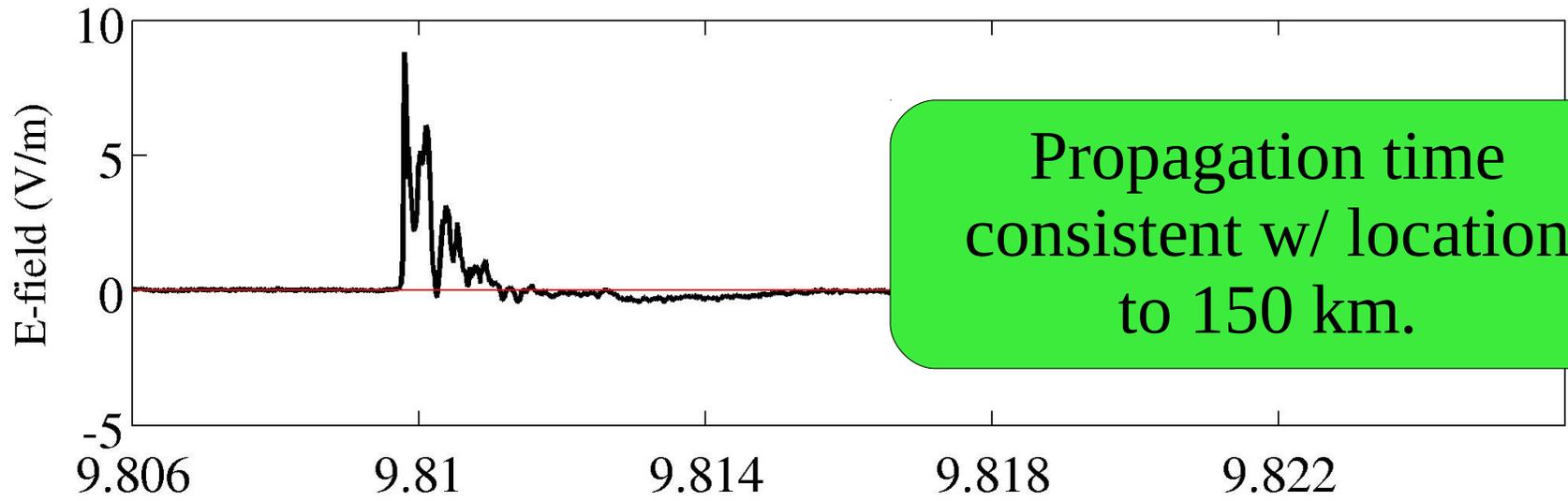
All sprites were “prompt” (delays  $< 5$  millisecc).

Distance dependence of E and B is  $1/r$ .

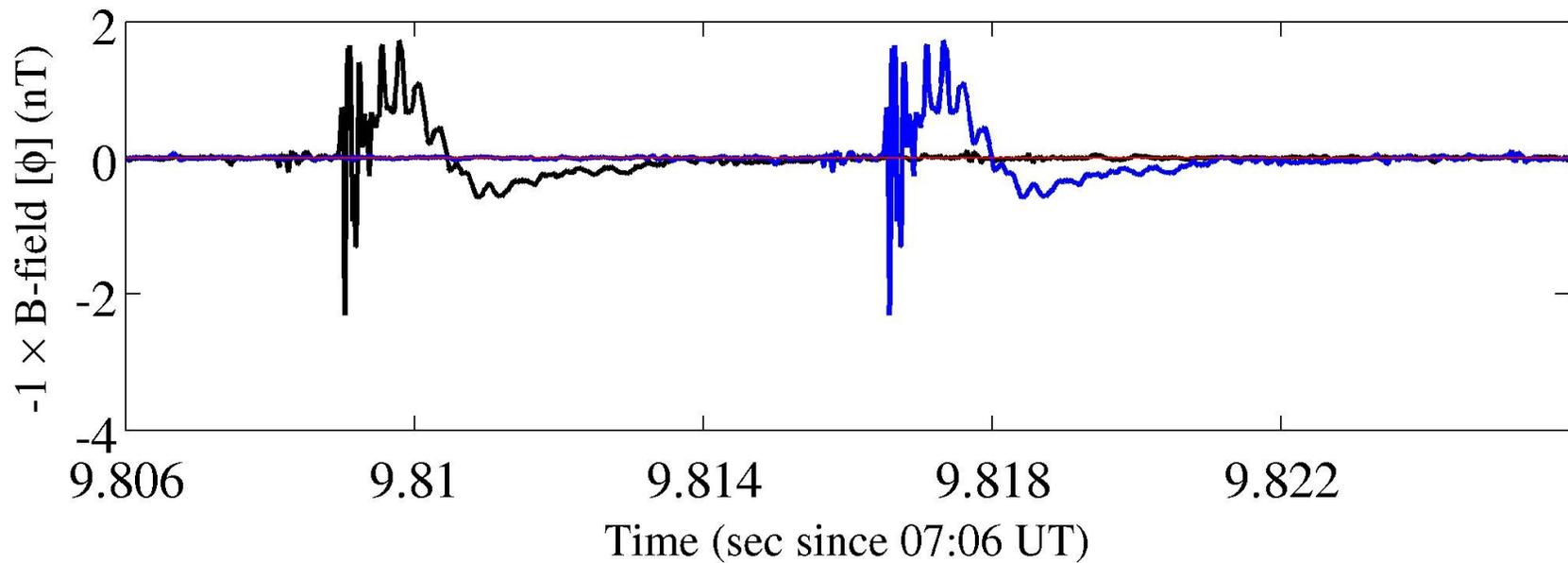
$B = E/c$  as expected.

# Event "A"

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Duke VLF Station



# Instrumentation

<b>Description</b>	<b>Time Resolution</b>
Telescopic video (Phantom7)	80 $\mu s$
Langmuir Electric Field-change array	20 $\mu s$
Duke VLF facility	10 $\mu s$
National Lightning Detection Network	1000 $\mu s$