



---

The Space Congress® Proceedings

2012 (42nd) A New Beginning

---

Dec 7th, 4:00 PM

## Summary of 2011 Direct and Nearby Lightening Strikes to Launch Complex 39B

Carlos T. Mata

Angel G. Mata

Follow this and additional works at: <https://commons.erau.edu/space-congress-proceedings>

---

### Scholarly Commons Citation

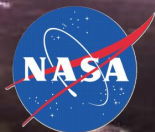
Mata, Carlos T. and Mata, Angel G., "Summary of 2011 Direct and Nearby Lightening Strikes to Launch Complex 39B" (2012). *The Space Congress® Proceedings*. 3.

<https://commons.erau.edu/space-congress-proceedings/proceedings-2012-42nd/december-07-2012/3>

This Event is brought to you for free and open access by the Conferences at Scholarly Commons. It has been accepted for inclusion in The Space Congress® Proceedings by an authorized administrator of Scholarly Commons. For more information, please contact [commons@erau.edu](mailto:commons@erau.edu).

**EMBRY-RIDDLE**  
Aeronautical University™  
SCHOLARLY COMMONS

# Summary of 2011 Direct and Nearby Lightning Strikes to Launch Complex 39B, Kennedy Space Center, Florida



Dr. Carlos T. Mata

WX Lead

Angel G. Mata

WX

2012



# Introduction

## Introduction

- Instrument. Overview and Setup
- Lightning Instrument.
- Meteo. Instrument.

## Chronological Milestones

## Acquired Lightning Data

## Statistics

## Selected Events

- Direct
- Nearby

## Conclusions

During early deployment, 2011, the LC39B lightning instrumentation was used to support the last two Space shuttle missions, STS-134 & STS-135

The day before STS-135 launch, LC39B LIS was used to locate nearby strikes to LC39A, preventing a launch scrub

Actual Status: Development and Implementation



Equipment used on the LC39B LIS (sensors, DAQ, cameras, etc.) have been tested at the ICLRT, at Camp Blanding, Florida, since 2009





# Instrumentation Overview and Setup

## 24/7 Continuous Operation

- Introduction
- Instrument Overview and Setup**
- Lightning Instrument.
- Meteo. Instrument.
- Chronological Milestones
- Acquired Lightning Data
- Statistics
- Selected Events
- Direct
- Nearby
- Conclusions



### Meteorological Instrumentation System (MIS):

- Continuous recording
- 1 S/s
- Local Storage Capability
- 26 remote sensors

### Lightning Instrumentation System (LIS):

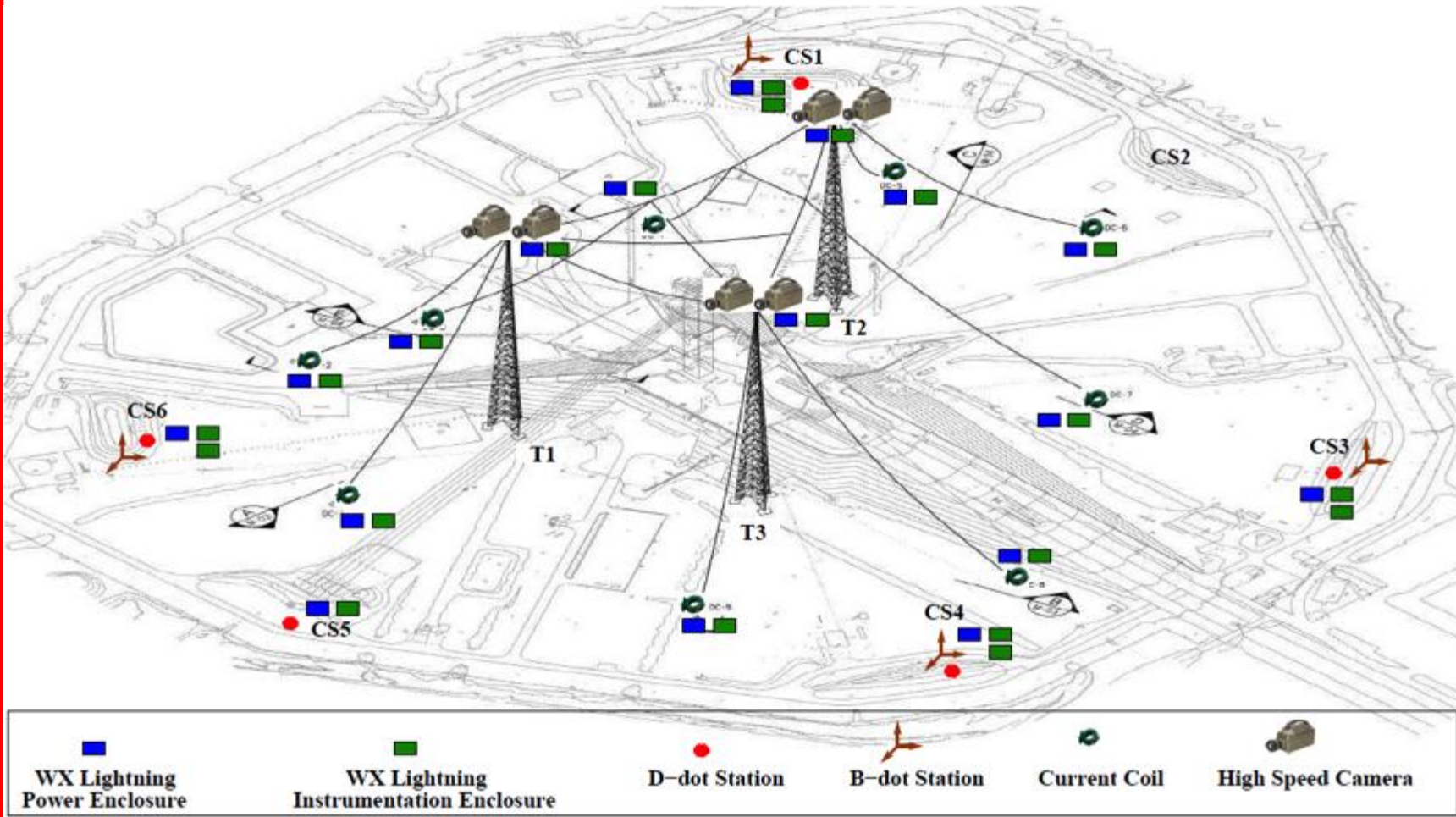
- Event driven
- 100MS/s
- Centralized Storage
- 31 remote sensors





# Lightning Instrumentation

- Introduction
- Instrument. Overview and Setup
- Lightning Instrument.**
- Meteo. Instrument.
- Chronological Milestones
- Acquired Lightning Data
- Statistics
- Selected Events
- Direct
- Nearby
- Conclusions



A few more High Speed Cameras:

- Roof of VAB
- LCC Firing Room 1



# Meteorological Instrumentation

Introduction

Instrument.  
Overview  
and Setup  
Lightning  
Instrument.

**Meteo.  
Instrument.**

Chronological  
Milestones

Acquired  
Lightning  
Data

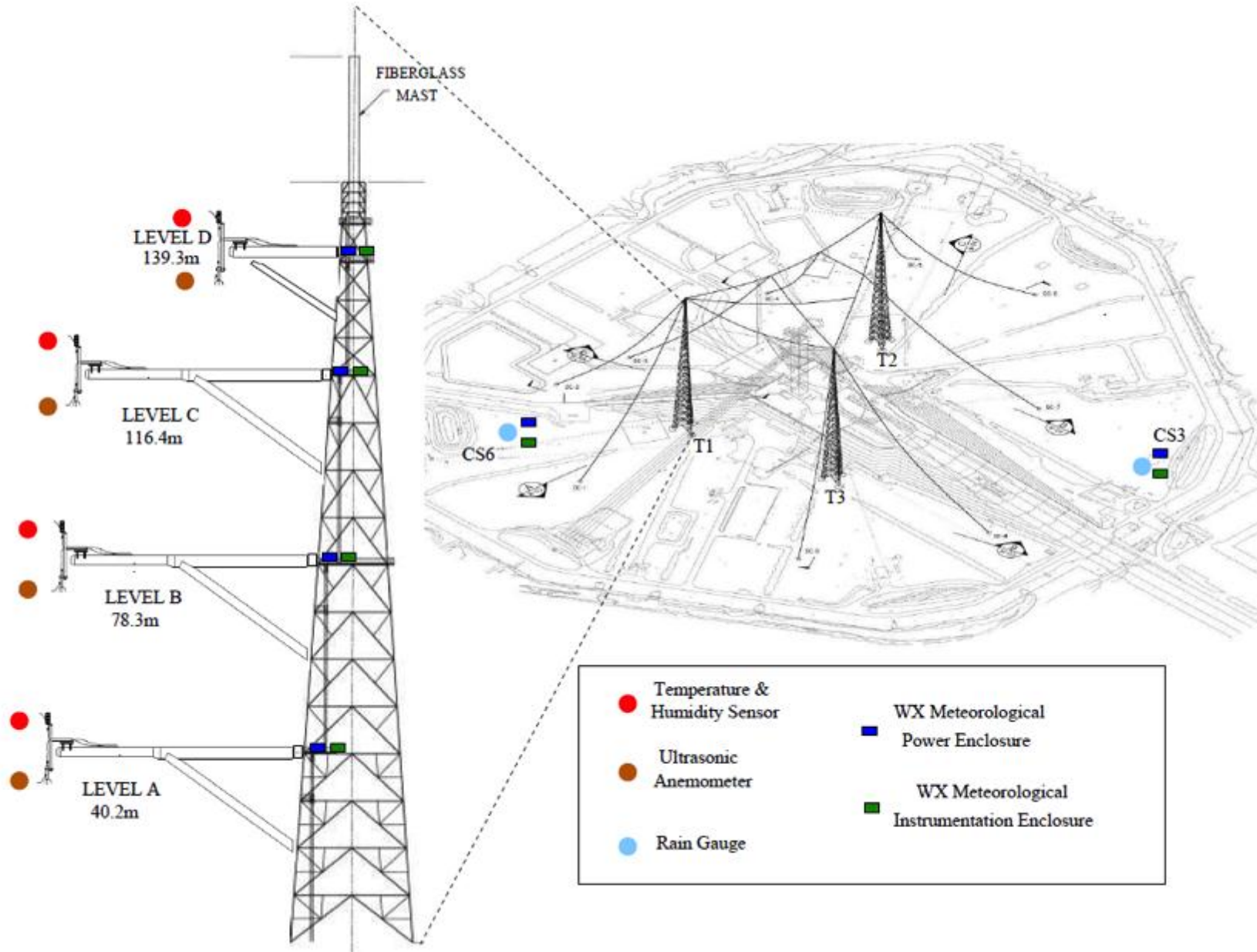
Statistics

Selected  
Events

Direct

Nearby

Conclusions







# Chronological Milestones

	<b>Action</b>	<b>Time</b>	
Introduction	LPS Design	2007	
Instrument. Overview and Setup	LPS Construction, meteorological and lightning instrumentation design	2008-2009	
	Lightning Instrument.	Instrumentation fabrication, testing, and installation	2010
Meteo. Instrument.	DAQ installed	January 2011	
	Tower 1, four meteorological stations active	February 2011	
<b>Chronological Milestones</b>	All (9) downconductors instrumentation, towers 2 & 3 meteorological stations (8) and 2 (out of 6) high speed video cameras active	March 2011	
	Acquired Lightning Data	First and last nearby lightning strike recorded (2011)	Mar. 30 <sup>th</sup> & Oct. 10 <sup>th</sup>
Statistics	Partial DAQ Active	First and last direct lightning strike recorded (2011)	Mar. 31 <sup>th</sup> & Aug. 14 <sup>th</sup>
Selected Events	Direct	4 (out of 6) high speed camera and all (12) magnetic field measurements active	April 2011
	Nearby	All (6) high speed video cameras and all (10) rate of change of electric field measurements <sup>a</sup> active	May 2011
Conclusions	Meteorological data shown on OTV, additional trigger signal from LC39A and additional (temporary) high speed video camera in Launch Control Center (LCC)	June 2011	
	Full DAQ Active	1 (out of 2) rain gauge stations active	August 2011
	All (2) rain gauge stations active	September 2011	
	VAB camera installation	March 2012	
	Meteorological data sent to 45 <sup>th</sup> WS (expected)	October 2012	

WX Evaluation and Experimentation at the ICLRT

a. From May until July there were some electric field measurements troubleshooting, so, limited dE/dt measurements are available for this period.



# 2011 Acquired Lightning Data

## LC39B LIS

Mid-March until end of 2011

Triggered in 14 different days

Total of 48 lightning flashes  
With 89 return stroke

### Direct: 8 flashes with 19 RS

Towers: 5 flashes

Catenary/Downconductors: 3 flashes

3 single-stroke flashes

5 multiple-stroke flashes (min 2, max 8)

Only 1 flash (3 RS) striking the same point

2 strokes had two simultaneous attachment points

### Close nearby: 3 flashes with 6 RS

1 flash (all 4RS) striking the perimeter fence

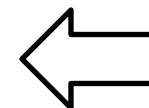
2 single-stroke flashes (one positive and one negative) terminating on the ground

### Nearby: 37 flashes with 64 RS

2 subsequent strokes with previous strokes terminating on the LC39B LPS

26 presumed single-stroke flashes (limited range of LC39B LIS)

14 multiple-strokes flashes (min 2, max 6)



Only direct and close nearby strikes to LC39B: **Negative** and **Positive** downward lightning

Introduction

Instrument. Overview and Setup

Lightning Instrument.

Meteo. Instrument.

Chronological Milestones

Acquired Lightning Data

Statistics

Selected Events

Direct  
Nearby

Conclusions





# 2011 Statistics

1km<sup>2</sup> area

- Introduction
- Instrument. Overview and Setup
- Lightning Instrument.
- Meteo. Instrument.
- Chronological Milestones
- Acquired Lightning Data
- Statistics**
- Selected Events
- Direct
- Nearby
- Conclusions

**11 flashes/km<sup>2</sup>/year**  
**9% positive flash**  
 55% multiple-stroke flashes  
 33% of multiple-stroke flashes had all RS terminating at the same location  
**25 strokes/km<sup>2</sup>/year with 4% positive strokes**

Direct attachments to LC39B LPS:  
 73% flashes with 18% multiple-terminations  
 76% strokes  
 63% multiple-stroke flashes  
 20% of multiple-stroke flashes had all RS terminating at the same location

**Total detected flashes: 48**  
**Total detected strokes: 89**

Sum of all donwconductor currents:  
 $I_{pk}$  median = 29.1 kA (N=16)  
 $t_{10-90\%}$  mean = 2.9  $\mu$ s [min 1  $\mu$ s, max 6  $\mu$ s]



Inter-stroke time [ms]

N	Min	Mean	Max
11 (direct)	23	84	180
14 (within 1km <sup>2</sup> )	17	71	180
38 (all detected)	1.5	116	389



# Selected Events

Introduction

Instrument.  
Overview  
and Setup

Lightning  
Instrument.

Meteo.  
Instrument.

Chronological  
Milestones

Acquired  
Lightning  
Data

Statistics

**Selected  
Events**

Direct

Nearby

Conclusions

## Direct Strike 7/07/2011

16:29:45.8432326 (UTC)

1<sup>st</sup> RS of a 3-RS flash (negative)



Two downconductor currents saturated  
Peak Current estimate: 200-220kA

## Nearby Strike 6/25/2011

00:02:25.903124 (UTC)

Single-RS flash (positive)



Data: {  
High Speed Video Camera Images  
Downconductor currents  
Electromagnetic waveforms (dH/dt and dE/dt)



# Direct Strike

16:29:45.8432326 (UTC)

Introduction

Instrument.  
Overview  
and Setup  
Lightning  
Instrument.  
Meteo.  
Instrument.

Chronological  
Milestones

Acquired  
Lightning  
Data

Statistics

Selected  
Events

**Direct**

Nearby

Conclusions



Frame 1; 562  $\mu$ s from Trigger





# Direct Strike

Introduction

Instrument.  
Overview  
and Setup  
Lightning  
Instrument.

Meteo.  
Instrument.

Chronological  
Milestones

Acquired  
Lightning  
Data

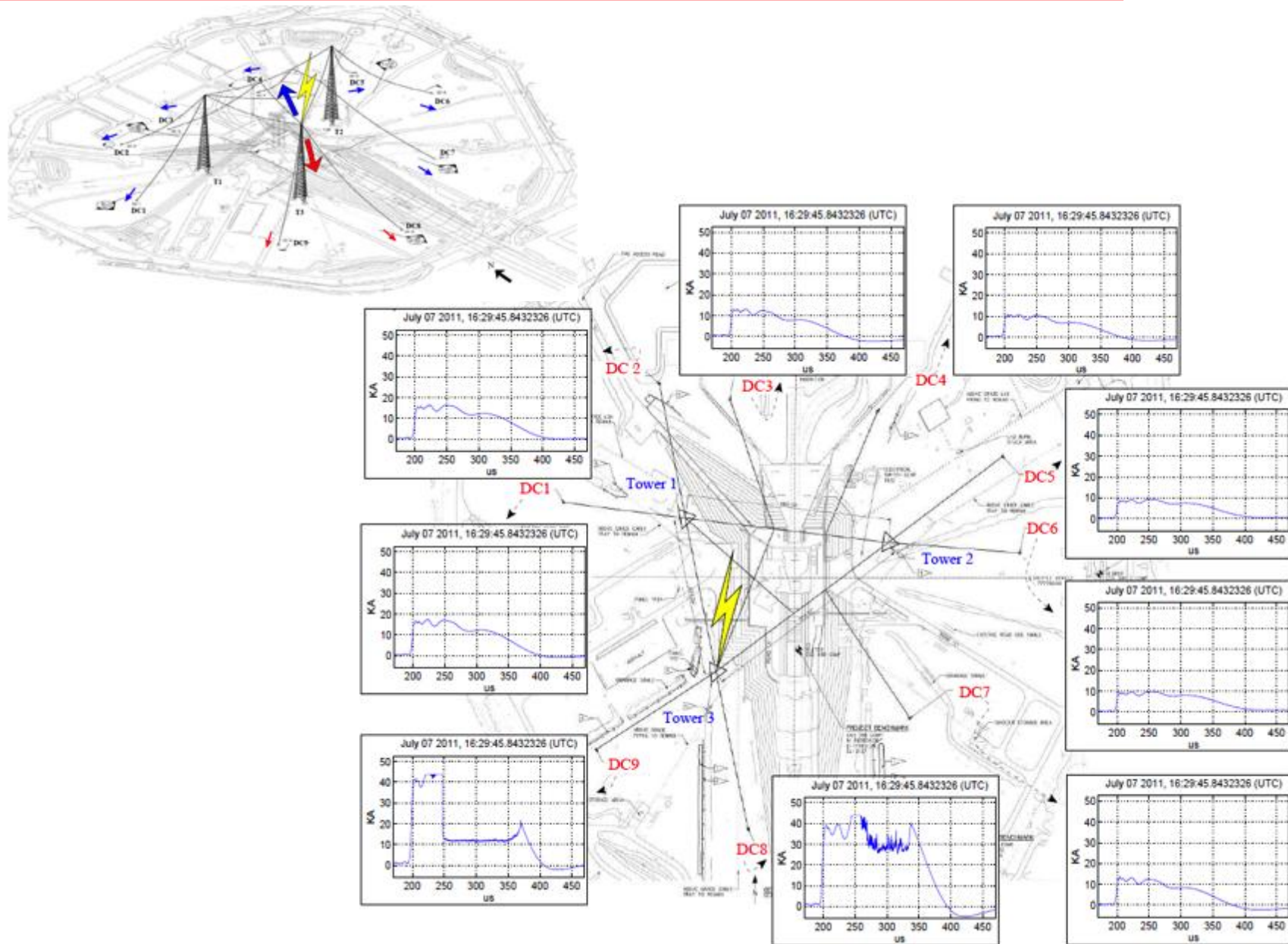
Statistics

Selected  
Events

**Direct**

Nearby

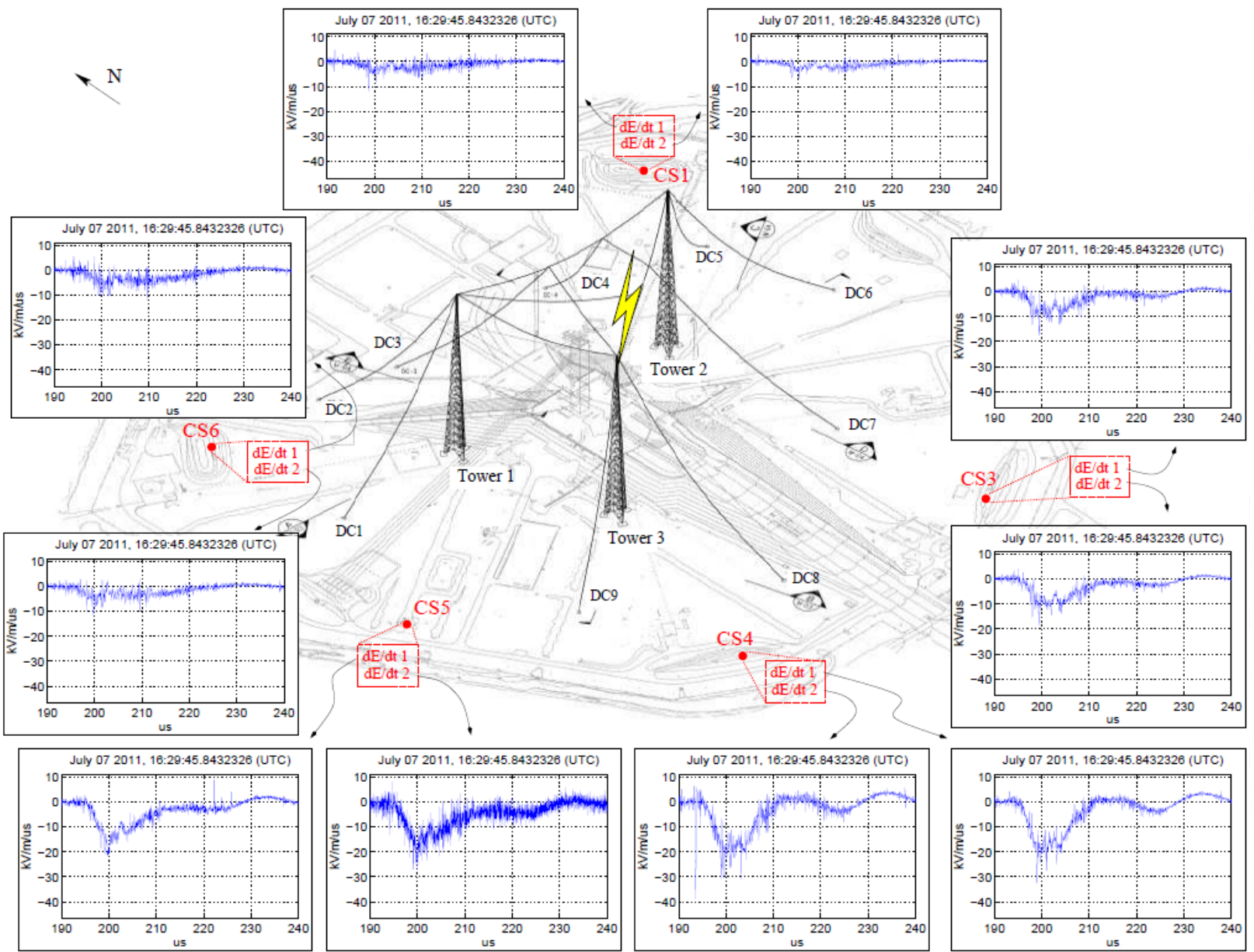
Conclusions





# Direct Strike, dE/dt

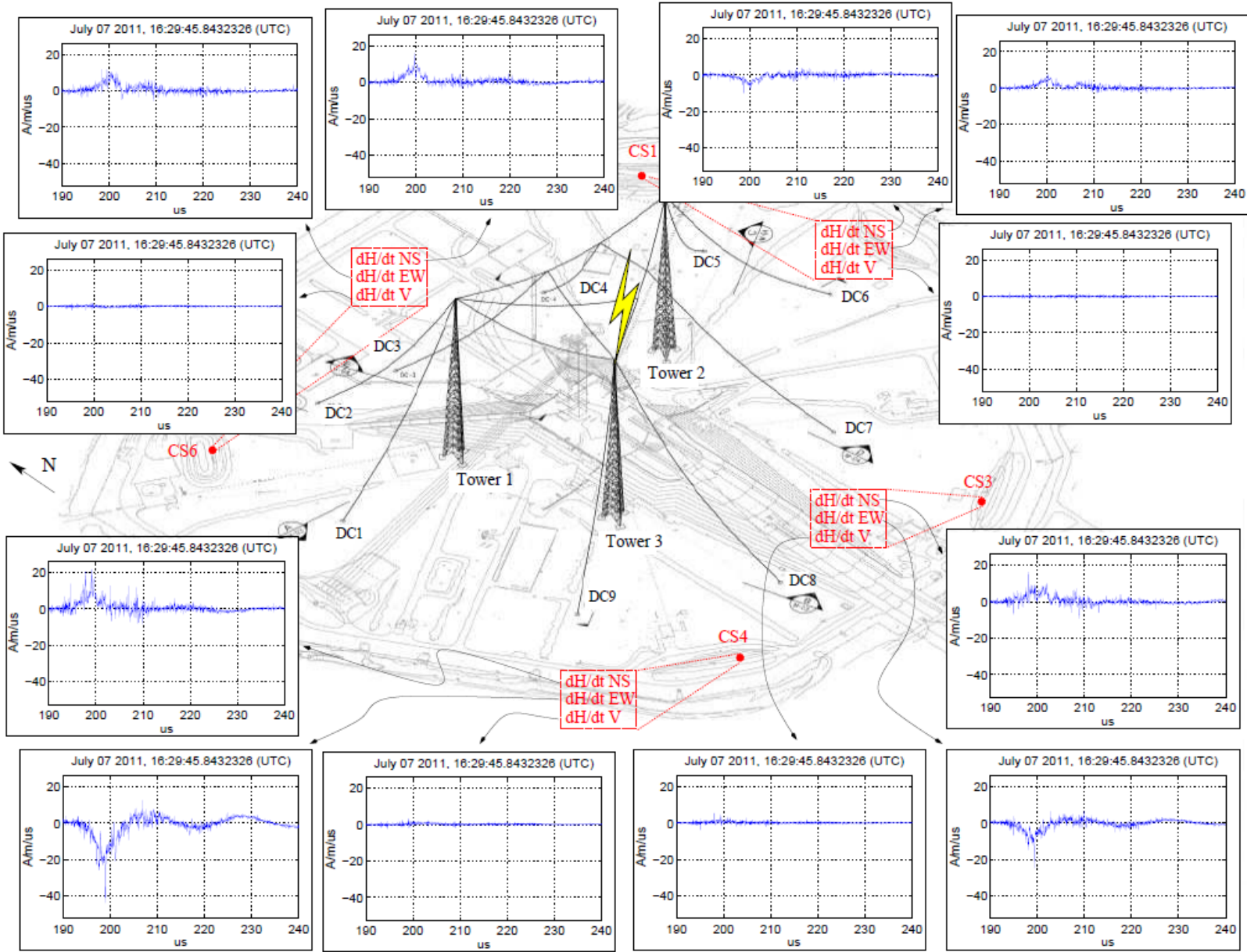
- Introduction
- Instrument.
- Overview and Setup
- Lightning Instrument.
- Meteo. Instrument.
- Chronological Milestones
- Acquired Lightning Data
- Statistics
- Selected Events
- Direct**
- Nearby
- Conclusions





# Direct Strike, dH/dt

- Introduction
- Instrument. Overview and Setup
- Lightning Instrument.
- Meteo. Instrument.
- Chronological Milestones
- Acquired Lightning Data
- Statistics
- Selected Events
- Direct**
- Nearby
- Conclusions







# Nearby Strike

Introduction

Instrument.  
Overview  
and Setup  
Lightning  
Instrument.

Meteo.  
Instrument.

Chronological  
Milestones

Acquired  
Lightning  
Data

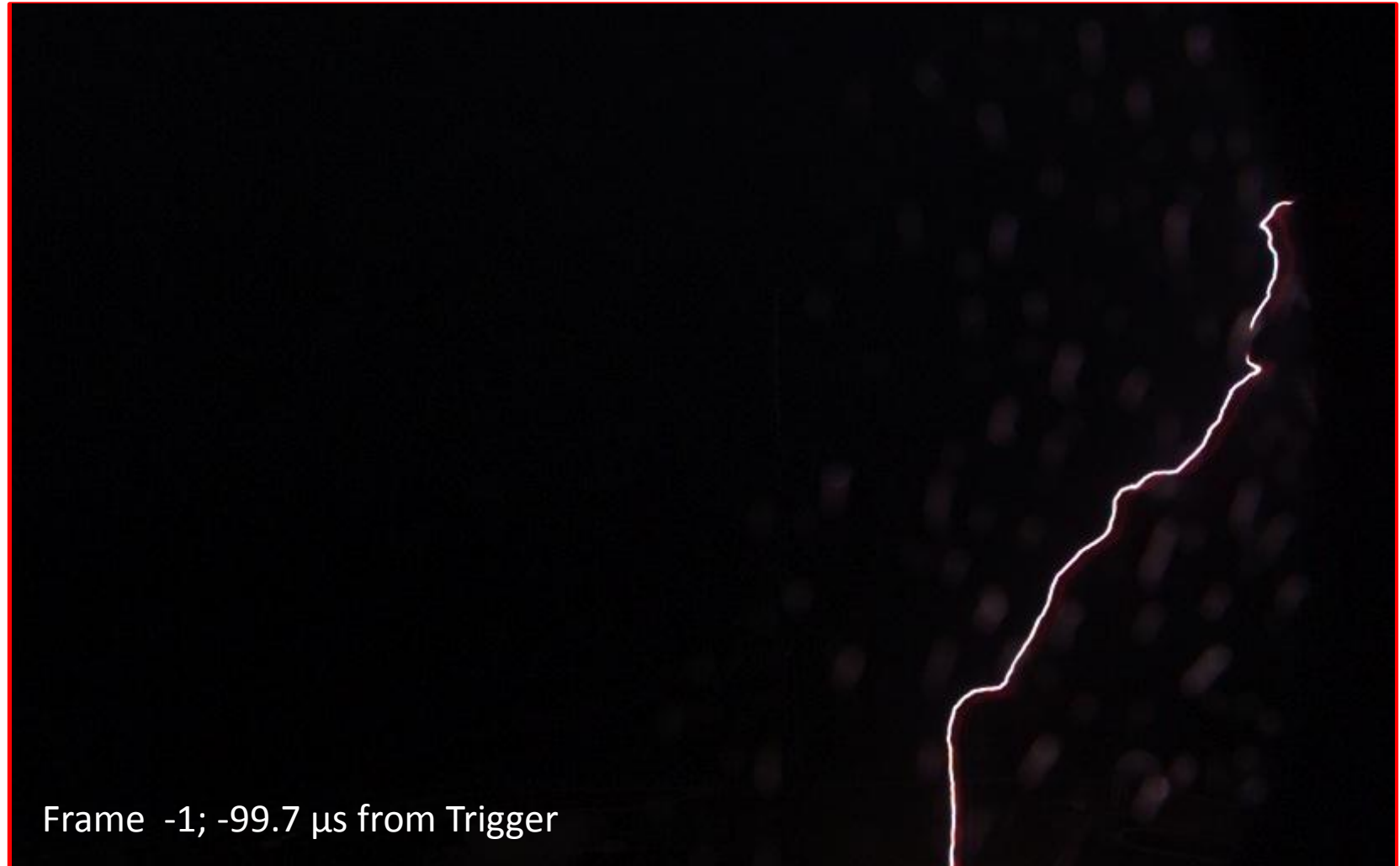
Statistics

Selected  
Events

Direct

**Nearby**

Conclusions



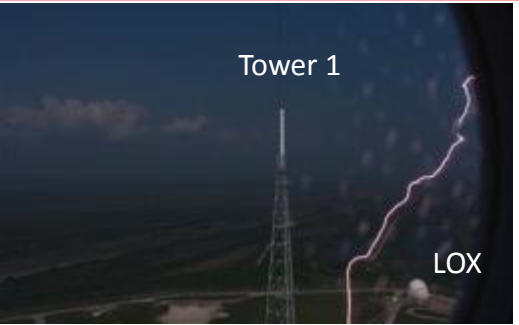
Frame -1; -99.7  $\mu$ s from Trigger



# Nearby Strike

- Introduction
- Instrument. Overview and Setup
- Lightning Instrument.
- Meteo. Instrument.
- Chronological Milestones
- Acquired Lightning Data
- Statistics
- Selected Events
- Direct
- Nearby
- Conclusions

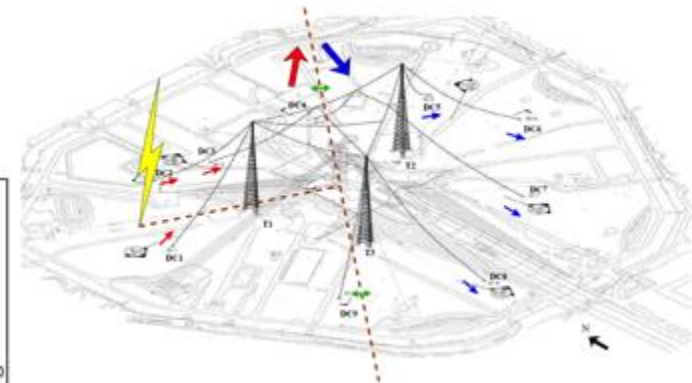
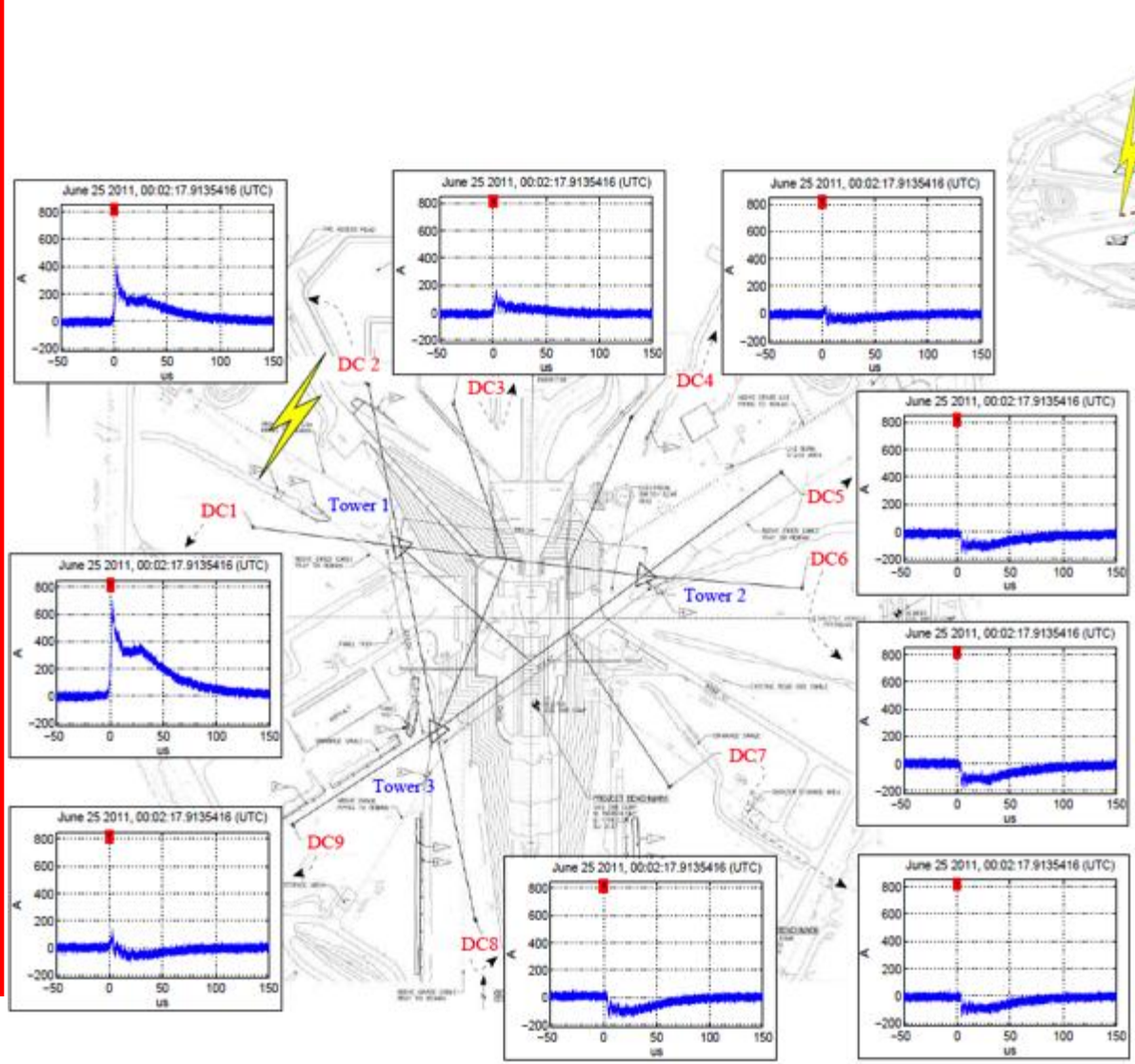
**S**  
**U**  
**P**  
**E**  
**R** **I**  
**I** **M**  
**M** **A**  
**P** **G**  
**O** **E**  
**S** **S**  
**E**  
**D**





# Nearby Strike

- Introduction
- Instrument.
- Overview and Setup
- Lightning Instrument.
- Meteo. Instrument.
- Chronological Milestones
- Acquired Lightning Data
- Statistics
- Selected Events
- Direct
- Nearby**
- Conclusions







# Nearby Strike, dE/dt

Introduction

Instrument.  
Overview  
and Setup

Lightning  
Instrument.

Meteo.  
Instrument.

Chronological  
Milestones

Acquired  
Lightning  
Data

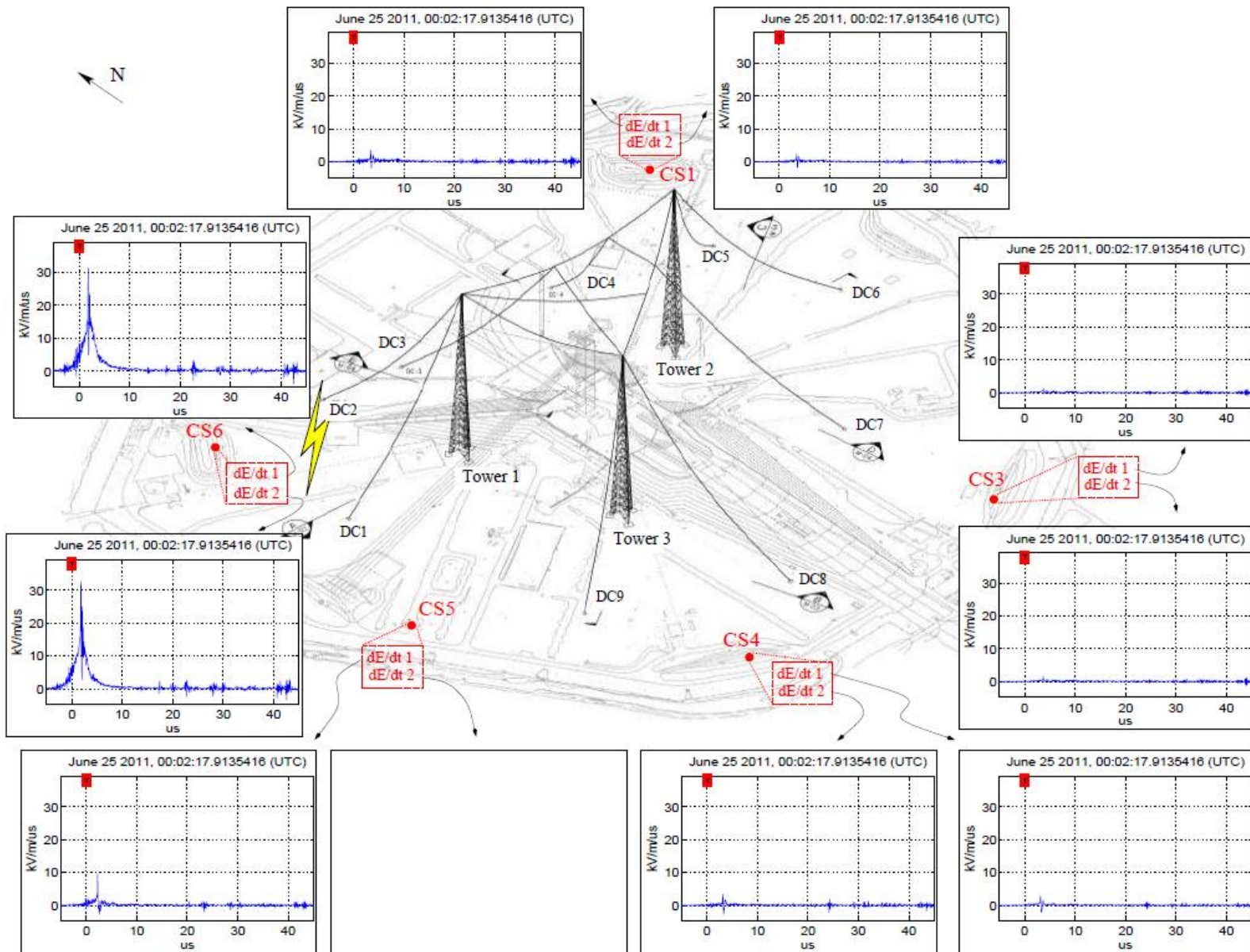
Statistics

Selected  
Events

Direct

**Nearby**

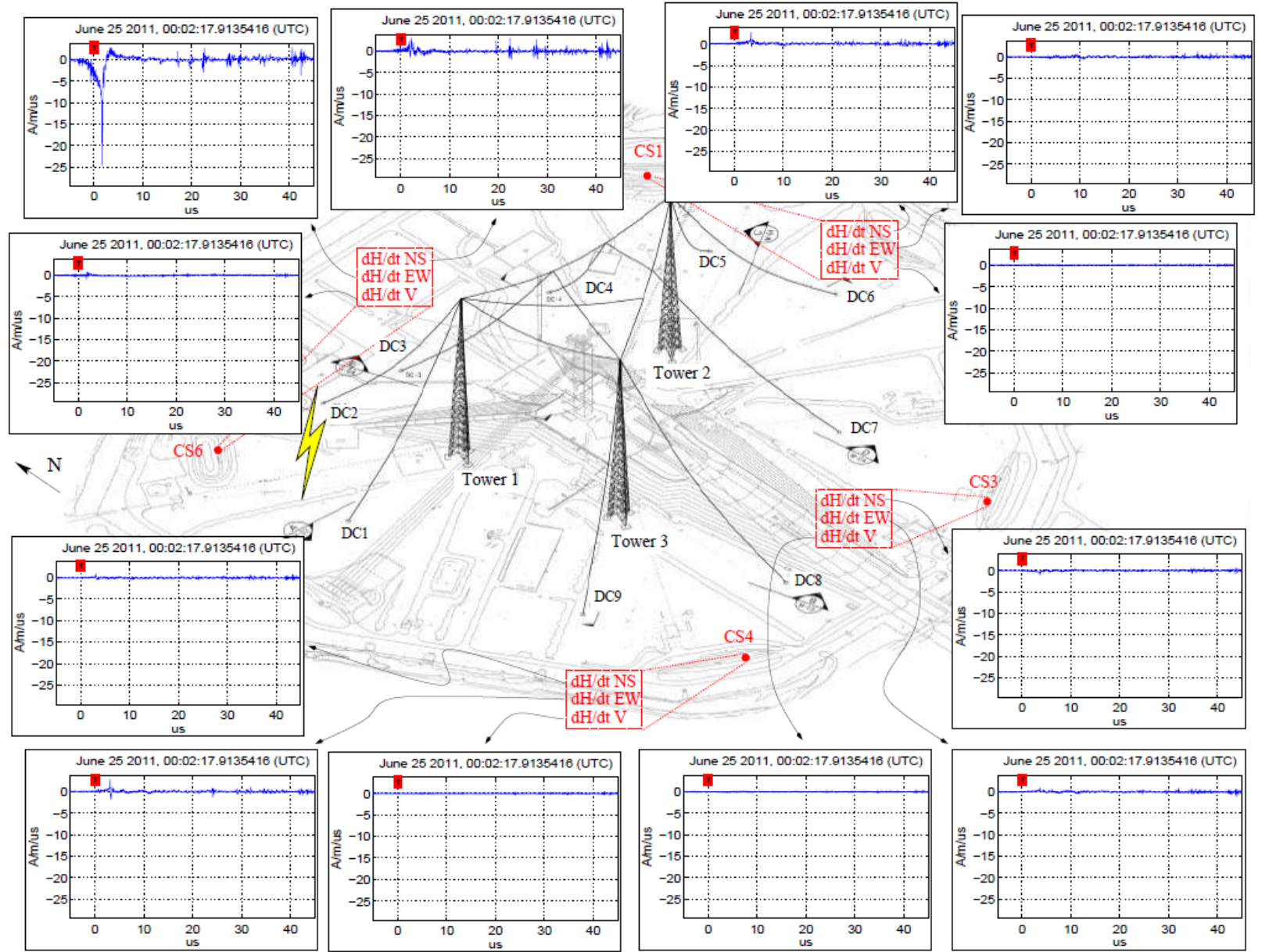
Conclusions





# Nearby Strike, dH/dt

- Introduction
- Instrument.
- Overview and Setup
- Lightning Instrument.
- Meteo. Instrument.
- Chronological Milestones
- Acquired Lightning Data
- Statistics
- Selected Events
- Direct
- Nearby**
- Conclusions





# Simultaneous Attachment







# Simultaneous Attachment





# Simultaneous Attachment





# Simultaneous Attachment







# Simultaneous Attachment





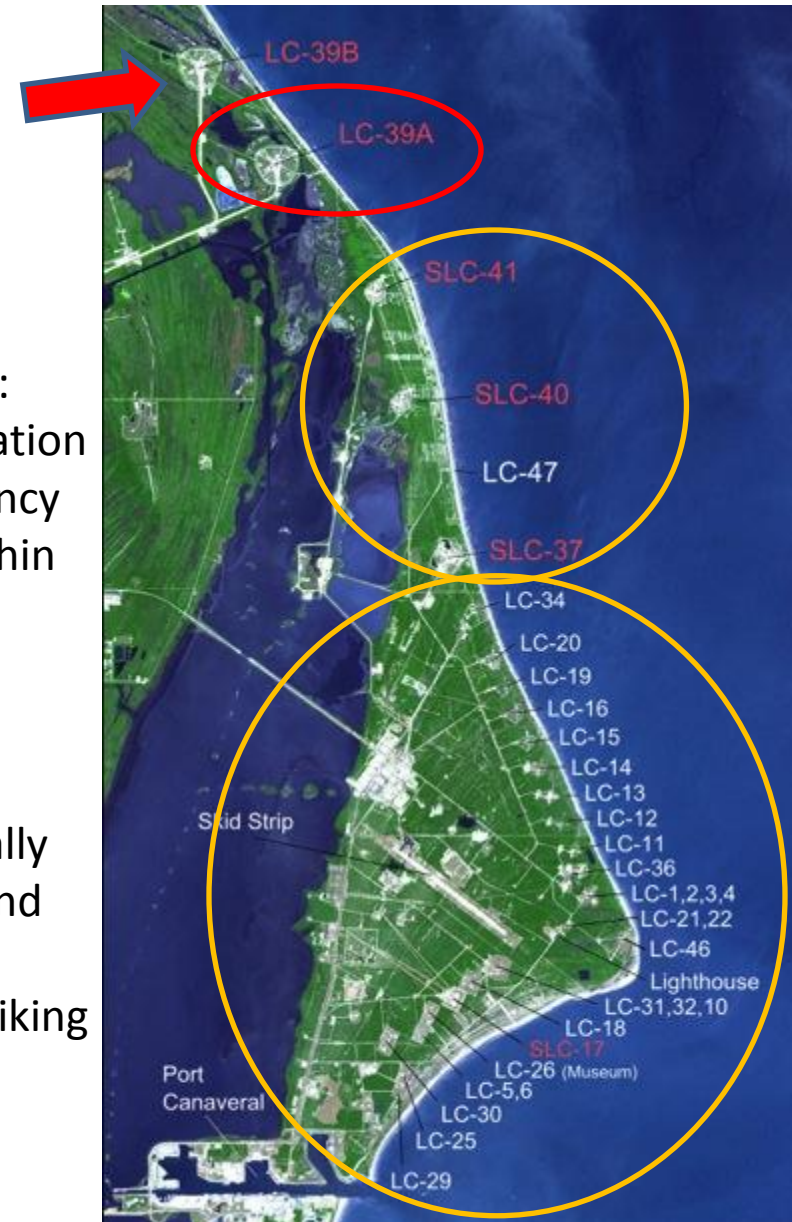
# Conclusions

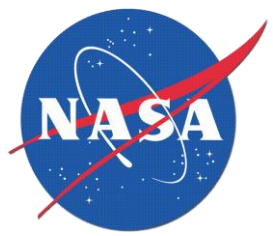
- Introduction
- Instrument. Overview and Setup
- Lightning Instrument.
- Meteo. Instrument.
- Chronological Milestones
- Acquired Lightning Data
- Statistics
- Selected Events
- Direct
- Nearby
- Conclusions**

## LC39B LPS

In less than one year after initial deployment:

- First comprehensive lightning instrumentation system at KSC with 100% detection efficiency
- Sub-meter lightning location accuracy within LC39B perimeter
- Building a comprehensive data base of lightning strikes to ground, water, and tall objects
- Has created increased interest to potentially deploy similar systems throughout **KSC** and **CCAFS**
- Optimize lightning protection systems, striking distance





Thank You

Questions







# LIS Requirements

Introduction

Instrument.  
Overview  
and Setup  
Lightning  
Instrument.  
Meteo.  
Instrument.

Chronological  
Milestones

Acquired  
Lightning  
Data

Statistics

Selected  
Events

Direct  
Nearby

Conclusions

Backups

- Immune to lightning strikes
- High detection efficiency  $\approx 100\%$ , no dead time
- Highly Accurate:
  - $\approx 95\%$ , error  $< 2$  meters (High-Speed Cameras)
  - $\approx 5\%$ , error  $< 5 - 10$  meters (Ddot & Hdot Sensors)
- Commercial Off-The-Shelf (COTS),
  - Transient Recorders\*
  - Digitizers\*
  - Current Sensors
  - Bdot and Ddot Sensors\*
  - High Speed Cameras\*
- Custom-made
  - Power Conditioning: Racks and Enclosures
  - High-Speed Camera Trigger Chassis



# MIS Requirements

Introduction

Instrument.  
Overview  
and Setup

Lightning  
Instrument.

Meteo.  
Instrument.

Chronological  
Milestones

Acquired  
Lightning  
Data

Statistics

Selected  
Events

Direct  
Nearby

Conclusions

Backups

Measurement	Range	Accuracy
Wind Speed	0.0 to 60 m/s	± 2% up to 25 m/s
Wind Direction	0 to 359 degrees	± 2 degrees
Air Temperature	-10 to 50 deg Celsius	0.1 deg Celsius (NIST traceable)
Relative Humidity	0 to 100 %	3% (from 10 to 90% RH)
Rain Rate	0 to 19.685 inches/hour	5% Accumulation
Rain Precipitation Accumulation	0 to 39.37 inches	5% Accumulation



# MIS Sensors' Specs

- Meteorological stations (CS CR1000):
  - Battery backed up
  - GILL Instruments HS WindObserver
    - 0-75 m/s (0-168 mph)
    - 0.01 m/s resolution
    - 0-12 m/s  $\pm$  1%; 12-25 m/s  $\pm$  2%; 25-45 m/s  $\pm$  3%; 45-65 m/s  $\pm$  4%; 65-80 m/s  $\pm$  6%
    - Resolution of 1° and accuracy of  $\pm$  2° @ 12 m/s, no dead band
  - R.M. Young 41372VC/VF with aspirated shield
    - Temperature range -10 to 60°C, accuracy  $\pm$  0.1°
    - RH range 0-100%, accuracy 3%
  - Optical Rain Gauge OSI ORG-815-DS
    - Range 0.1 to 500 mm/hr, resolution 0.001 mm, accuracy 5% accumulation

Introduction

Instrument.  
Overview  
and Setup

Lightning  
Instrument.

Meteo.  
Instrument.

Chronological  
Milestones

Acquired  
Lightning  
Data

Statistics

Selected  
Events

Direct  
Nearby

Conclusions

Backups





# Nearby Positive Strike (within LC39B)

Introduction

Instrument Overview and Setup

Lightning Instrument.

Meteo. Instrument.

Chronological Milestones

Acquired Lightning Data

Statistics

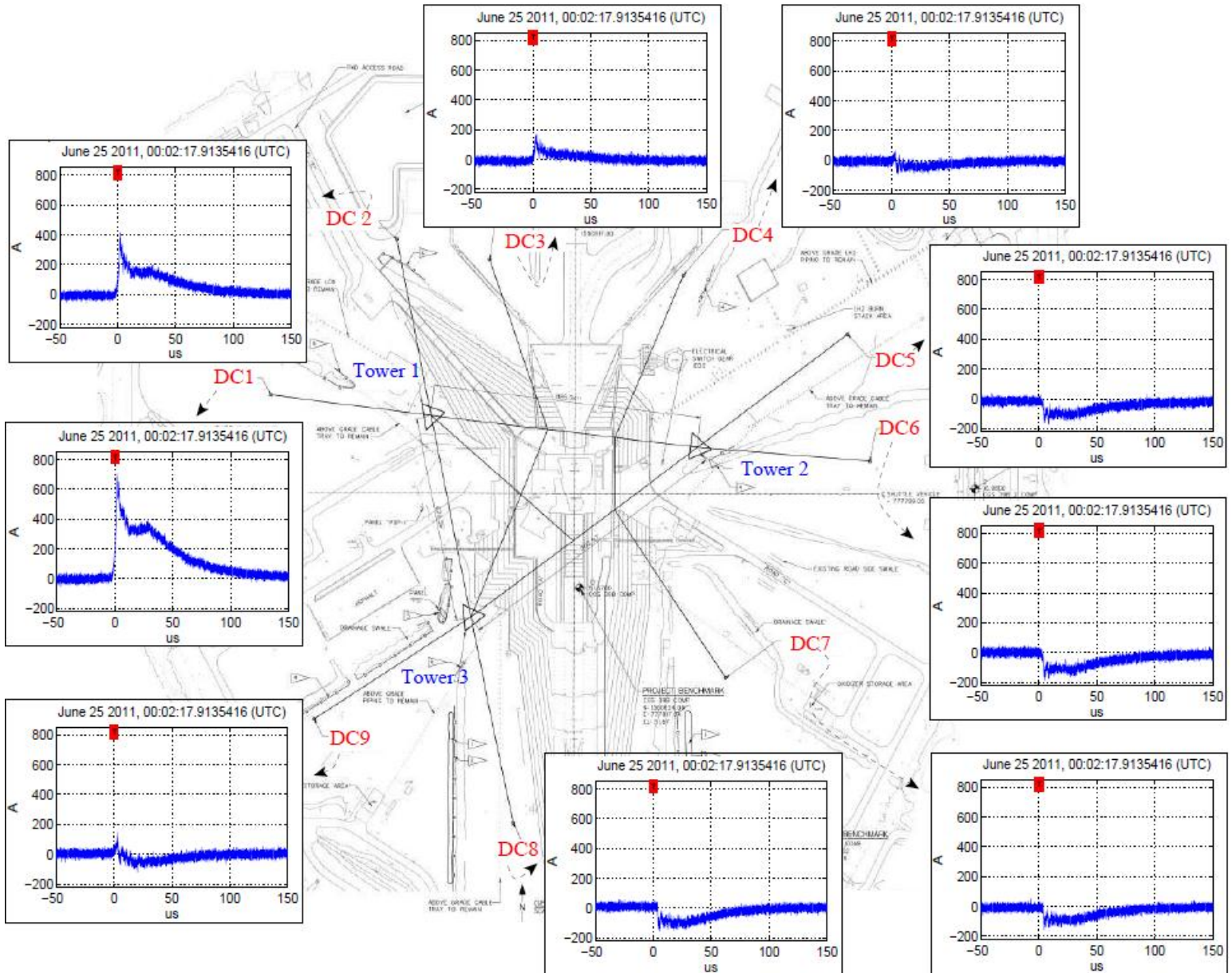
Selected Events

Direct

Nearby

Conclusions

Backups





# Direct Strike

Introduction

Instrument.  
Overview  
and Setup

Lightning  
Instrument.

Meteo.  
Instrument.

Chronological  
Milestones

Acquired  
Lightning  
Data

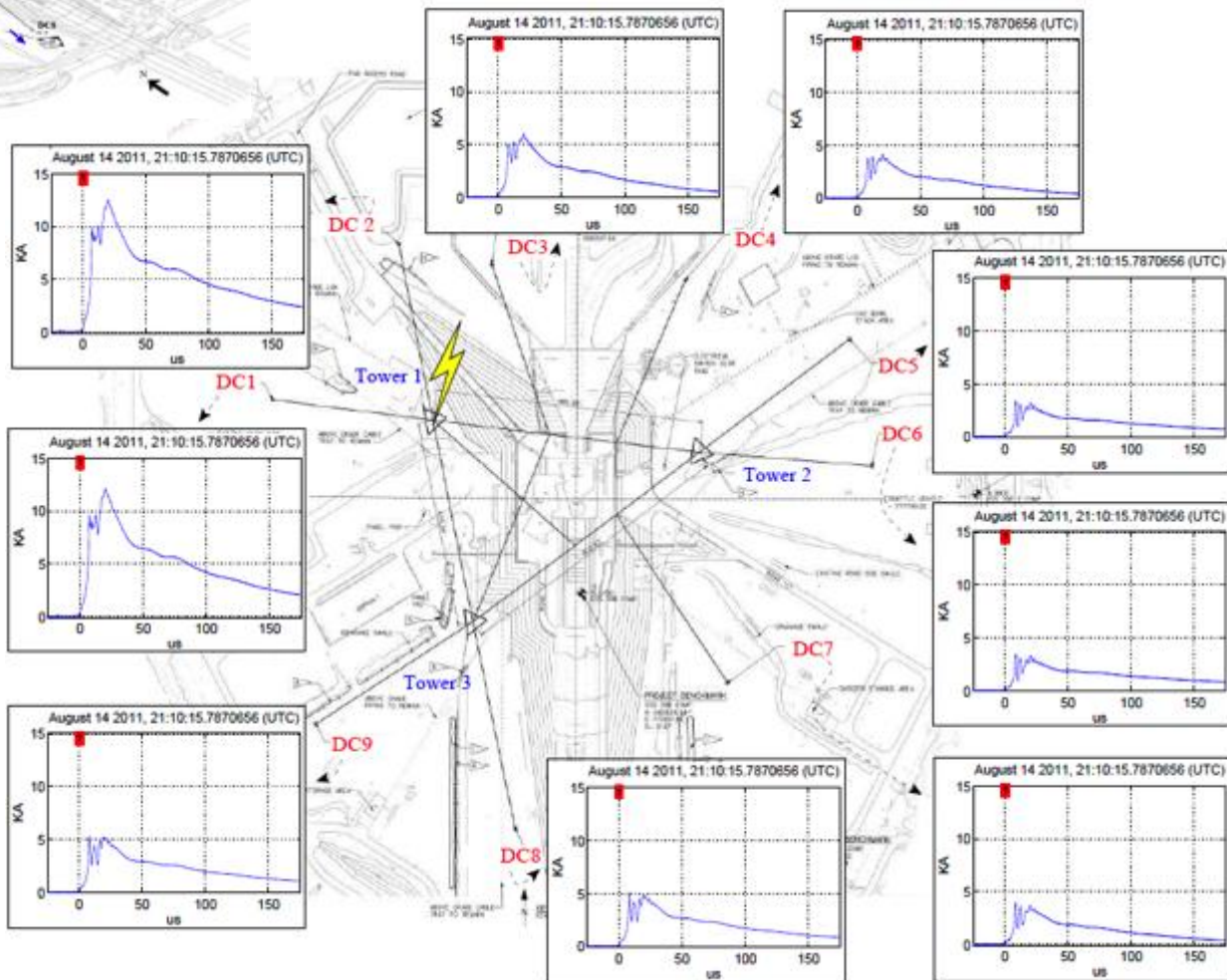
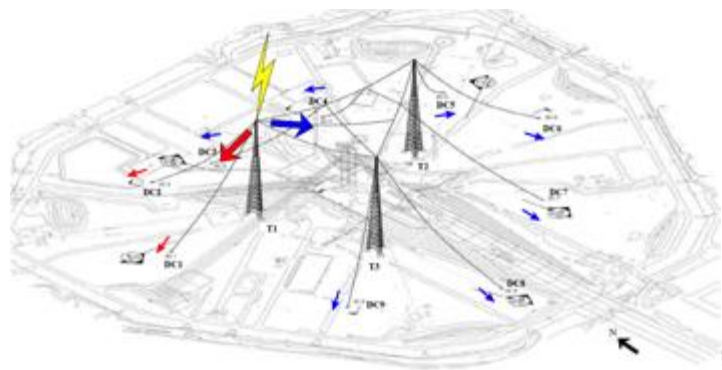
Statistics

Selected  
Events

**Direct**

Nearby

Conclusions







# Direct Strike

Introduction

Instrument.  
Overview  
and Setup  
Lightning  
Instrument.

Meteo.  
Instrument.

Chronological  
Milestones

Acquired  
Lightning  
Data

Statistics

Selected  
Events

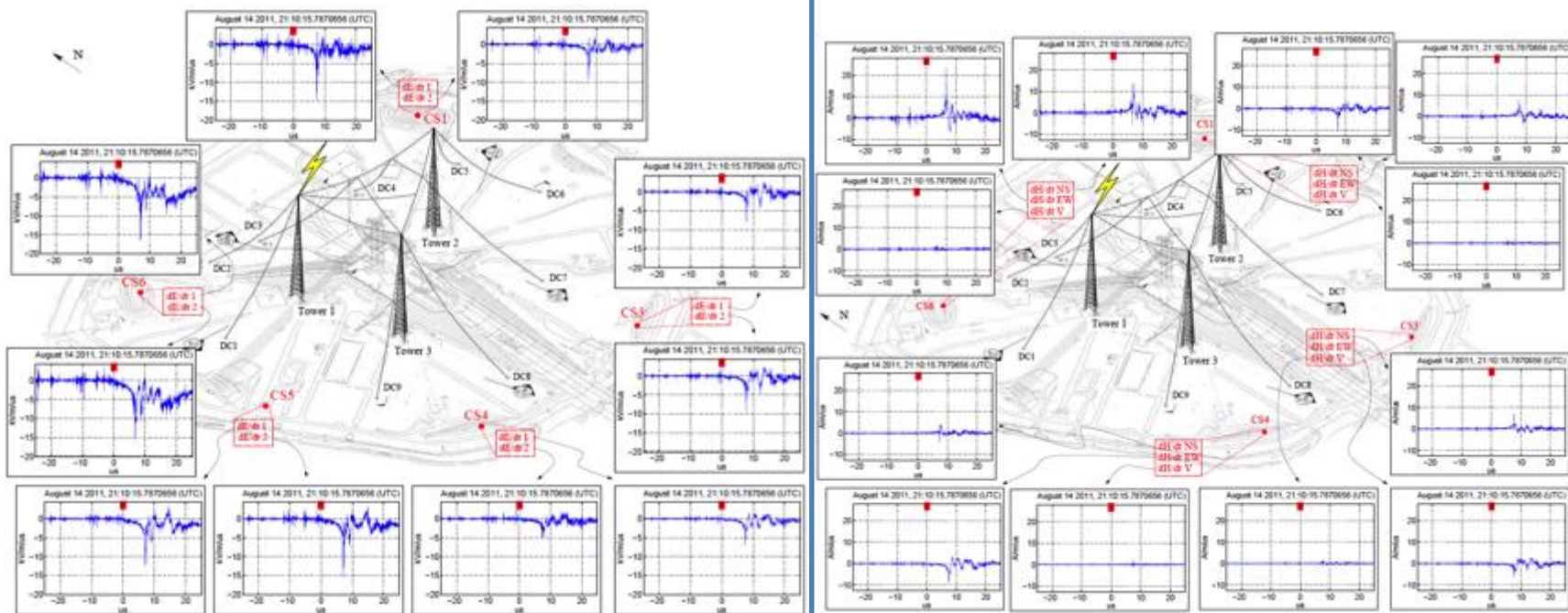
**Direct**

Nearby

Conclusions

$dE/dt$

$dH/dt$







# Nearby Strike

Introduction

Instrument.  
Overview  
and Setup

Lightning  
Instrument.

Meteo.  
Instrument.

Chronological  
Milestones

Acquired  
Lightning  
Data

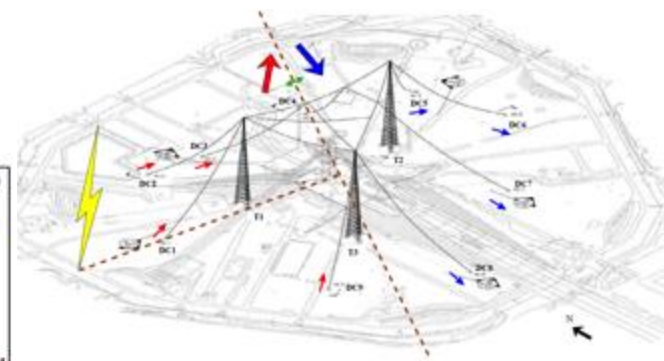
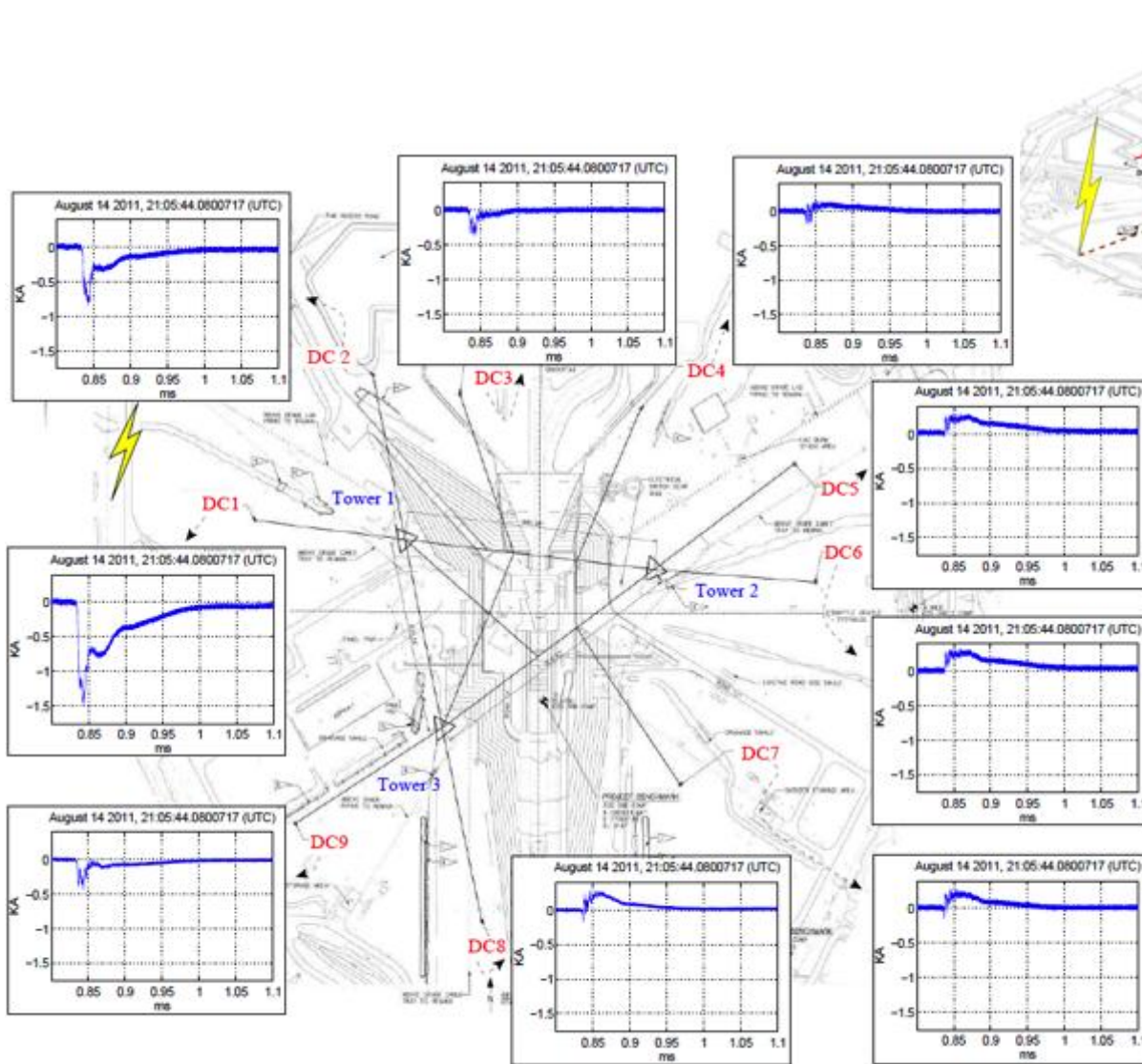
Statistics

Selected  
Events

Direct

**Nearby**

Conclusions





# Nearby Strike

- Introduction
- Instrument. Overview and Setup
- Lightning Instrument.
- Meteo. Instrument.
- Chronological Milestones
- Acquired Lightning Data
- Statistics
- Selected Events
- Direct Nearby
- Conclusions

dE/dt

dH/dt

