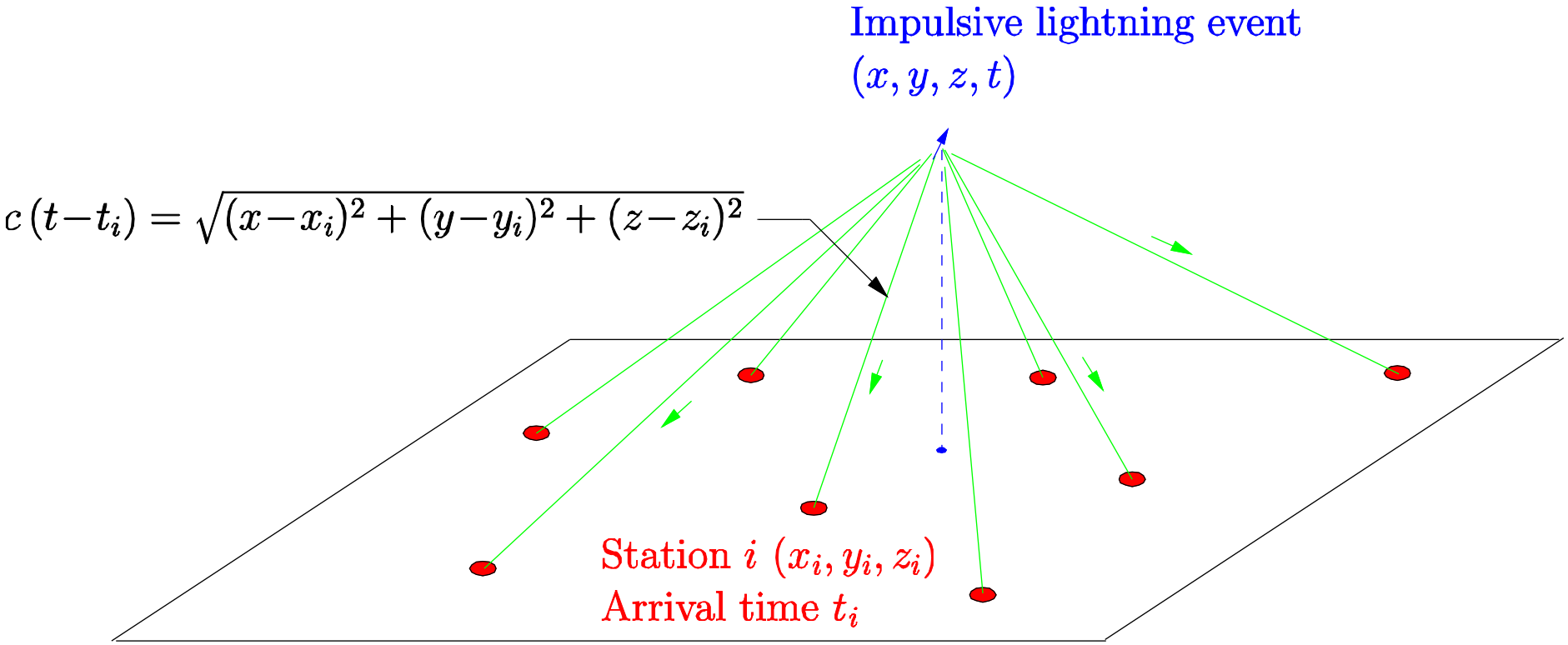
Status Report on Several Lightning Mapping Arrays

William Rison, Paul Krehbiel, Ron Thomas,
Graydon Aulich, Harald Edens
Langmuir Laboratory for Atmospheric Research
New Mexico Institute of Mining and Technology
Socorro, NM 87801

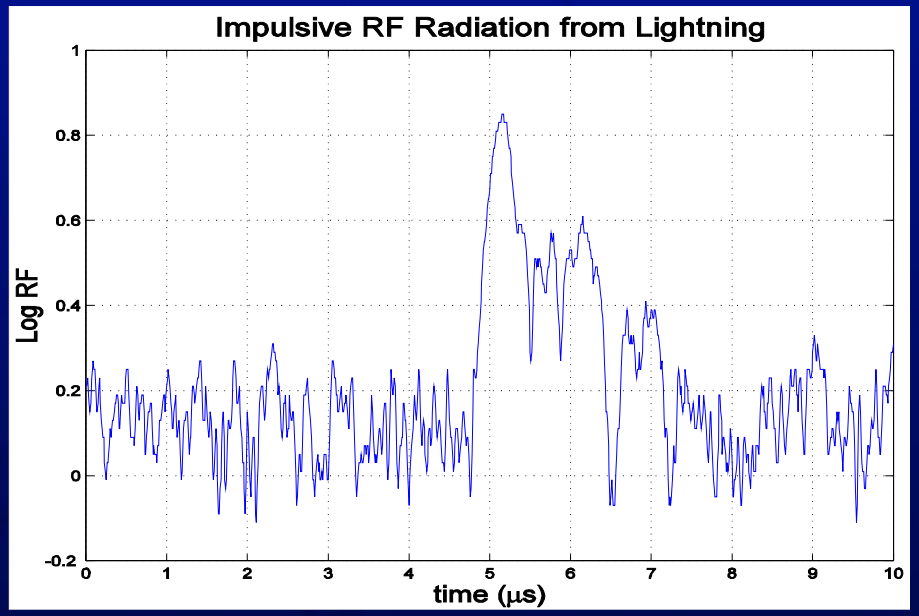
Southern Thunder 2011
Norman, OK July 11, 2011

Time-of-Arrival (TOA) technique:

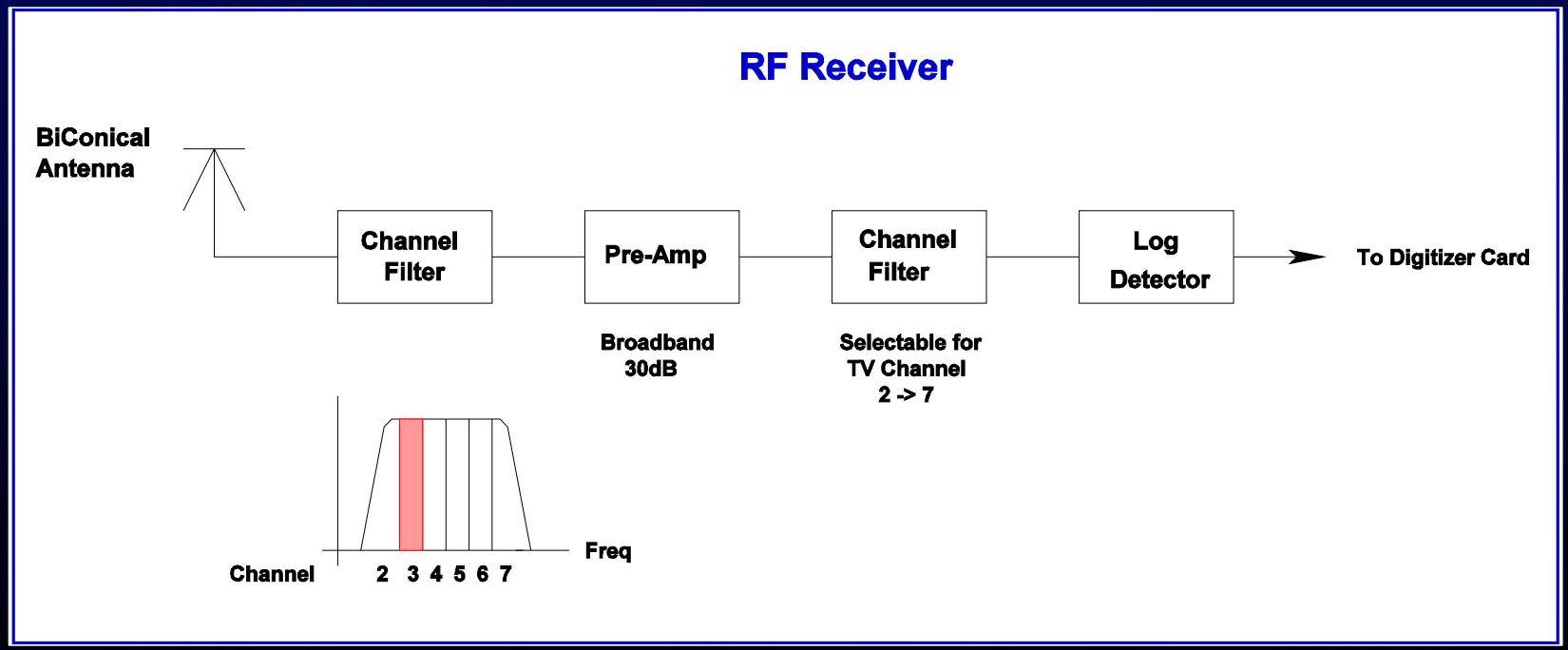


- Measure t_i at $N \geq 4$ locations (50 ns accuracy)
- Solve for x, y, z, t (4 unknowns)
- Inherently 3-dimensional technique

LMA Operation



- Listen in a locally unused TV channel
- Detect peak event in successive 80 microsecond time intervals
- Measure arrival time within 40 ns
- Up to 12,500 arrival times/second (100,000 in research mode)



Example of a highly dendritic negative cloud-to-ground (CG) flash

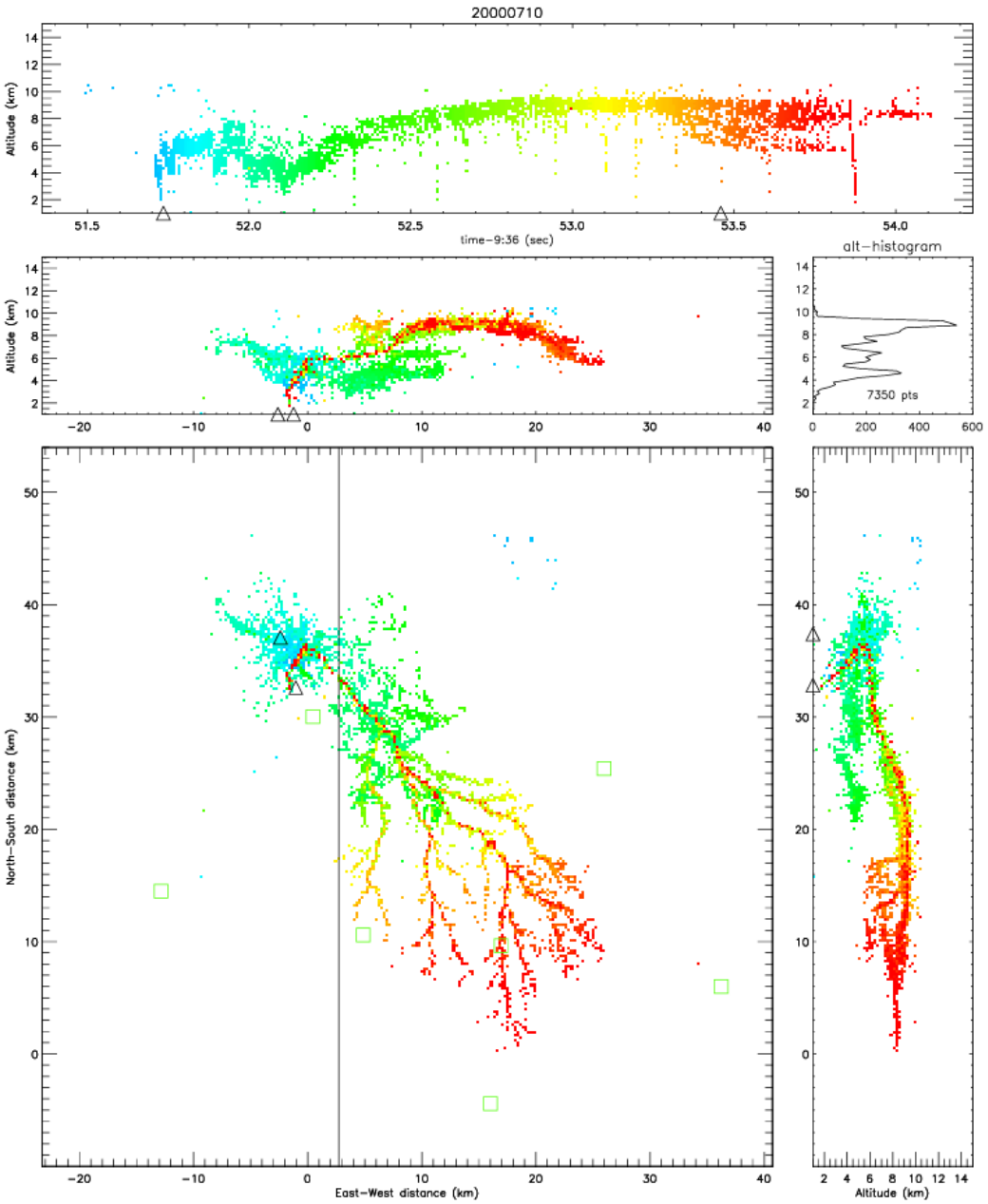
Height vs. time

Height vs. E-W

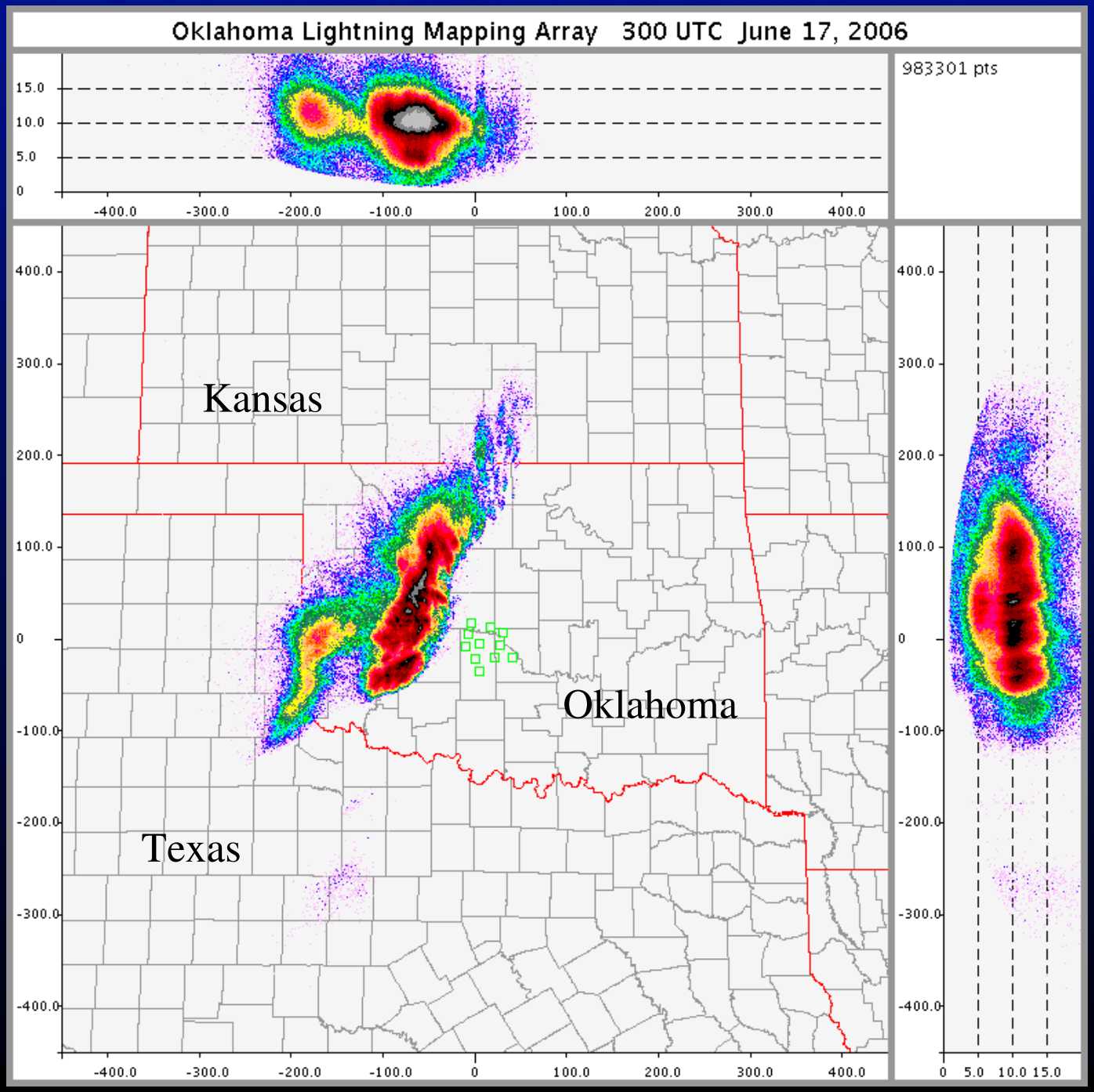
60 km extent,
2.5 sec duration,
7350 sources

Plan view

Height vs. N-S



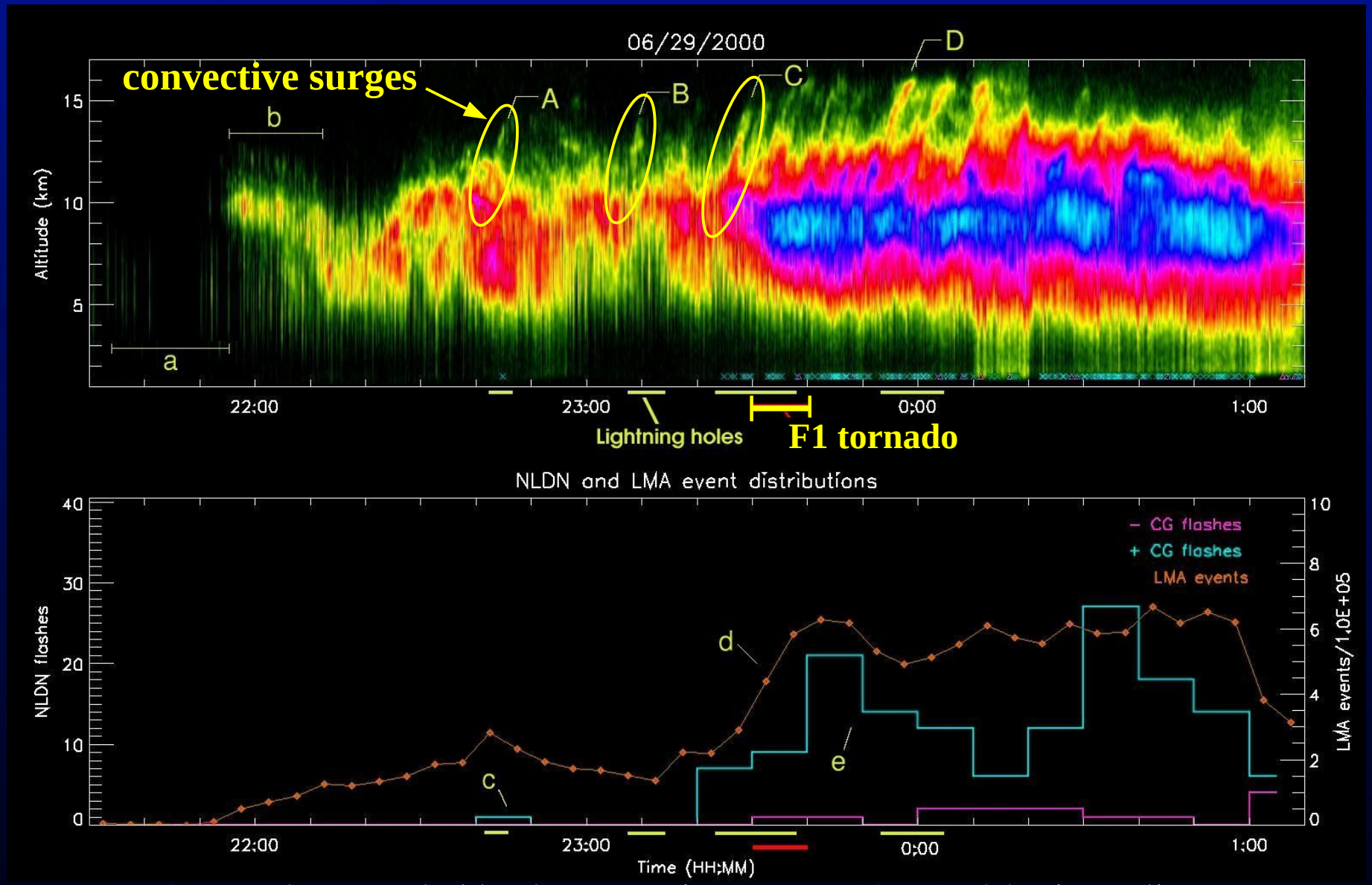
Oklahoma Lightning Mapping Array (OU, NSSL)



- Density of points display

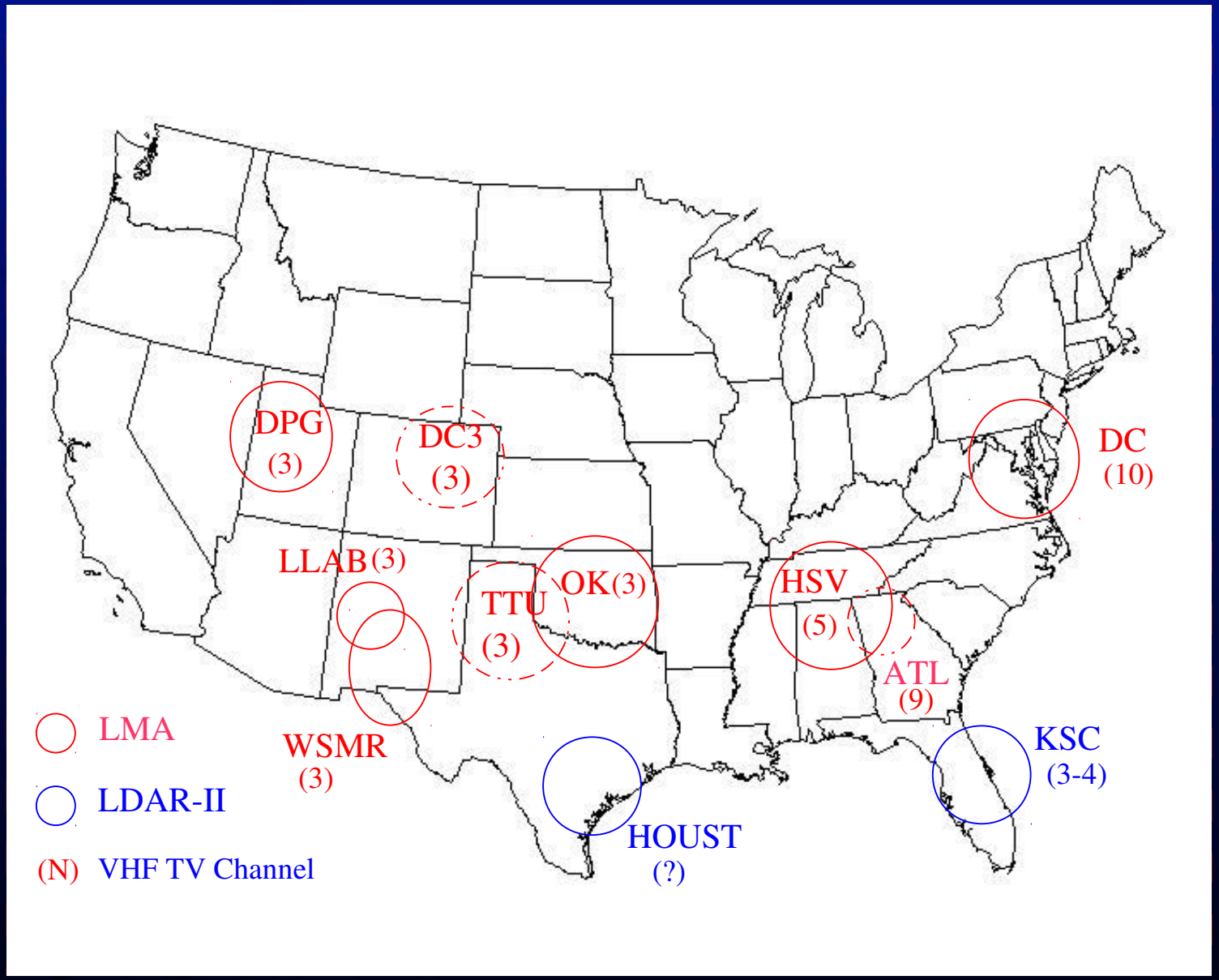
(http://lightning.nmt.edu/oklma)

Tornadic Storm, June 29, STEPS 2000: Height vs. time density plot

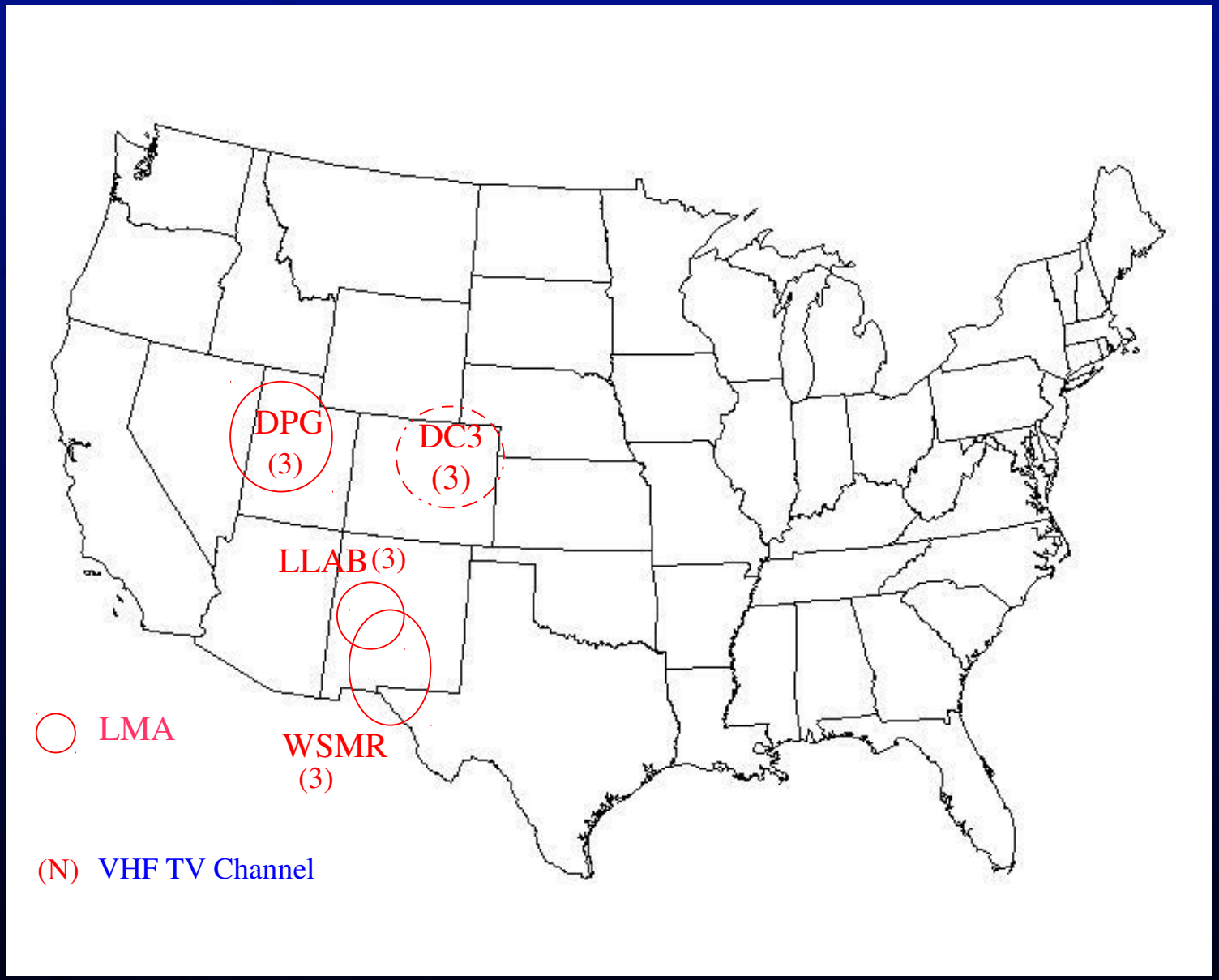


F1 tornado preceded by 2 convective surges (A, B) 45 min earlier; accompanied by 3rd surge and by onset of +CG discharges

VHF Time-Of-Arrival (TOA) Total Lightning Mapping Systems



VHF Time-Of-Arrival (TOA) Total Lightning Mapping Systems



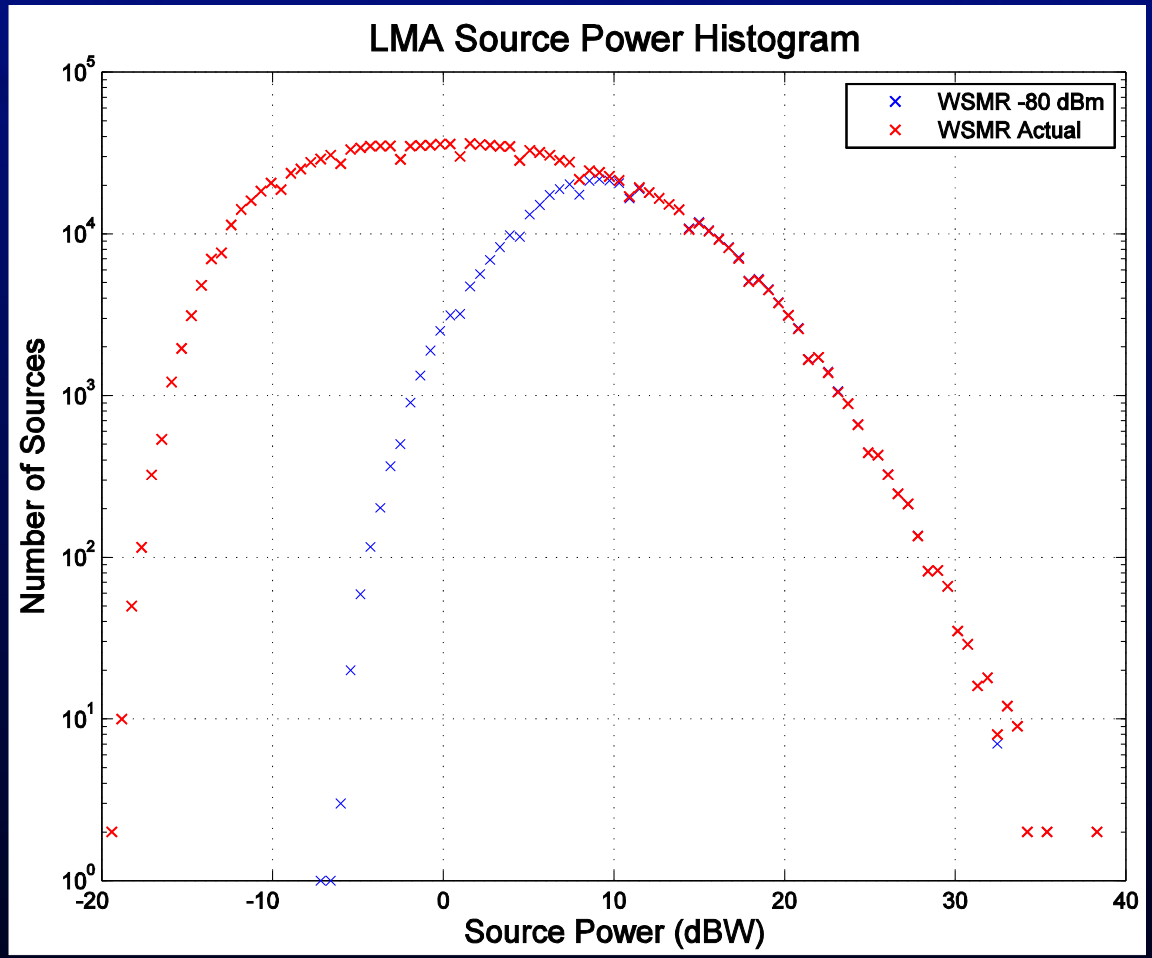
Practical Considerations

- VHF Frequency: Lightning measurements are best made in the lower VHF
  - Radiated source power decreases as ~$1/f^2$
  - Antenna gain decreases as $1/f^2$ [(1/2)-wave dipole antennas]
  - Decreased detectability, range in upper VHF
- Array Size
  - Station spacing of ~20 km necessary for 3D accuracy and good sensitivity
- Number of Stations
- – Better accuracy and detectability with more stations
  - Minimum number: 10
- Background Noise
  - Lower background gives higher sensitivity
  - Getting away from buildings lowers noise considerably
  - Newer deployments (Langmuir Lab, DPG, TTU, DC3) use solar power in order to get away from local noise sources

•WSMR Lightning Mapping Array

- Number of sources detected: 717316
- Number of sources at -80 dBm: 438162

Station	Noise Floor
C	-85 dBm
G	-89 dBm
H	-91 dBm
K	-82 dBm
L	-73 dBm
M	-82 dBm
P	-90 dBm
T	-73 dBm
W	-90 dBm



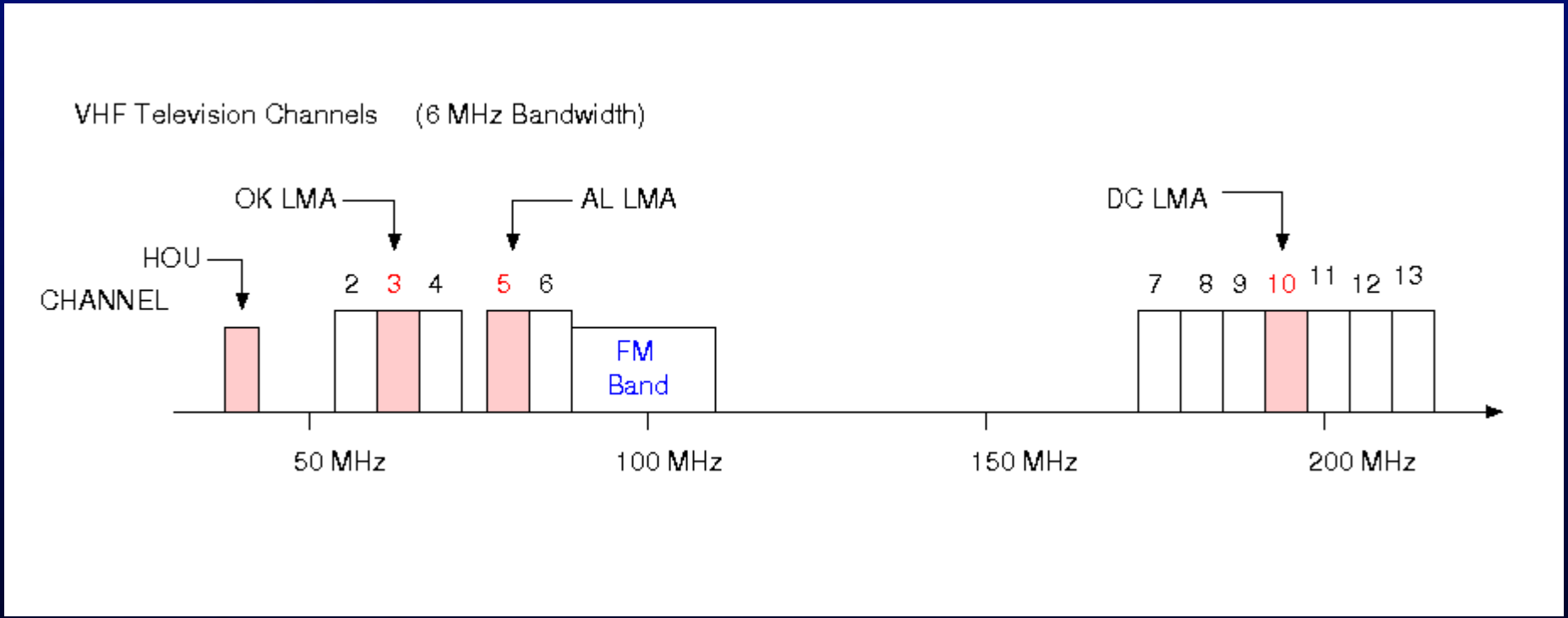
Solar Powered LMA Station

- Noise threshold: ~ -90 dBm

Practical Considerations (continued)

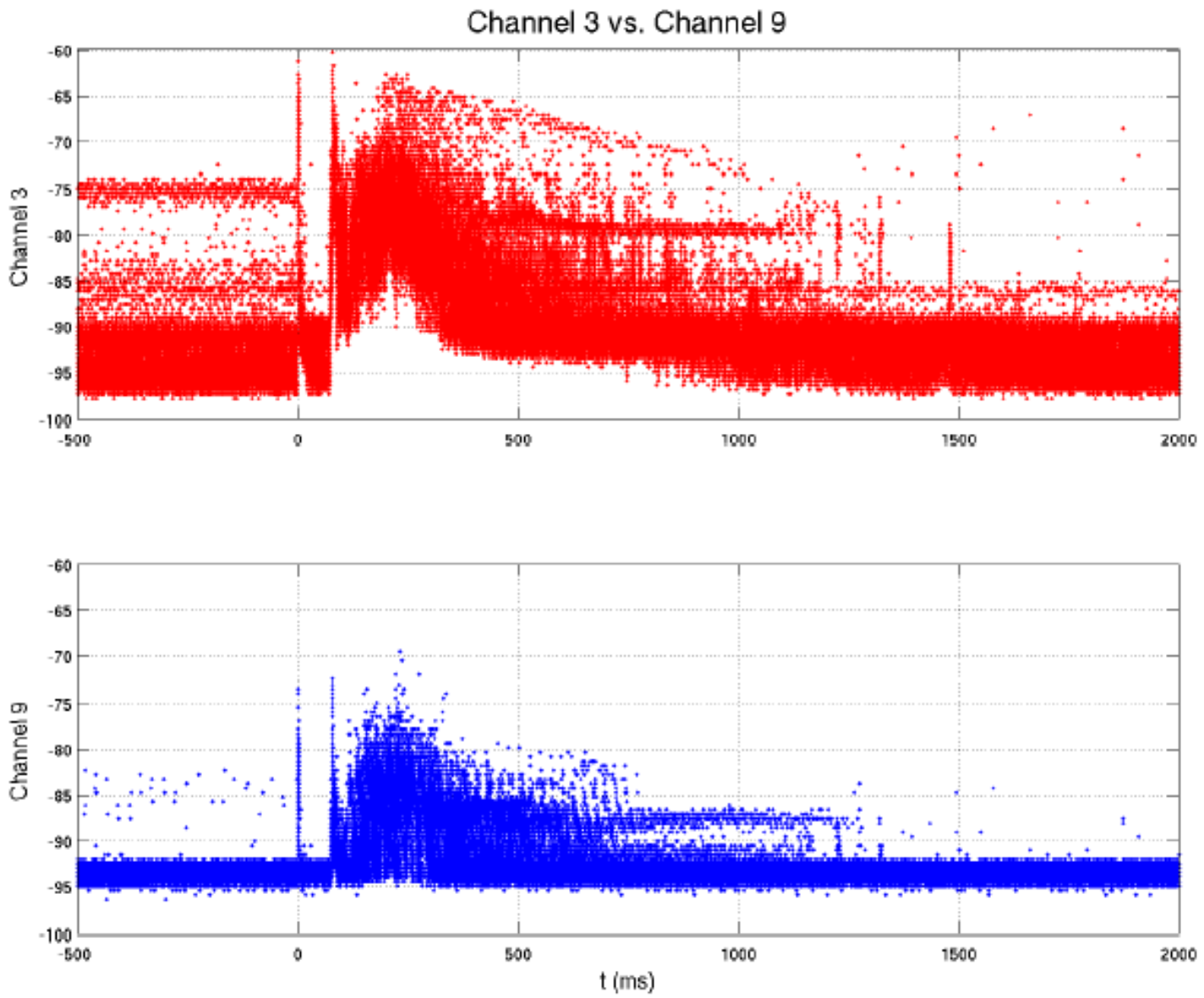
- Communications Link
  - Need 50 Kb/sec to each station for decimated real-time data
  - Need 1 Mb/sec for full data
  - 802.11 Wireless (OKLMA, NALMA)
  - Internet (DC)
  - Fiber Optic (WSMR)
  - Cell Phone Modem (DC3)

VHF Frequency Spectrum

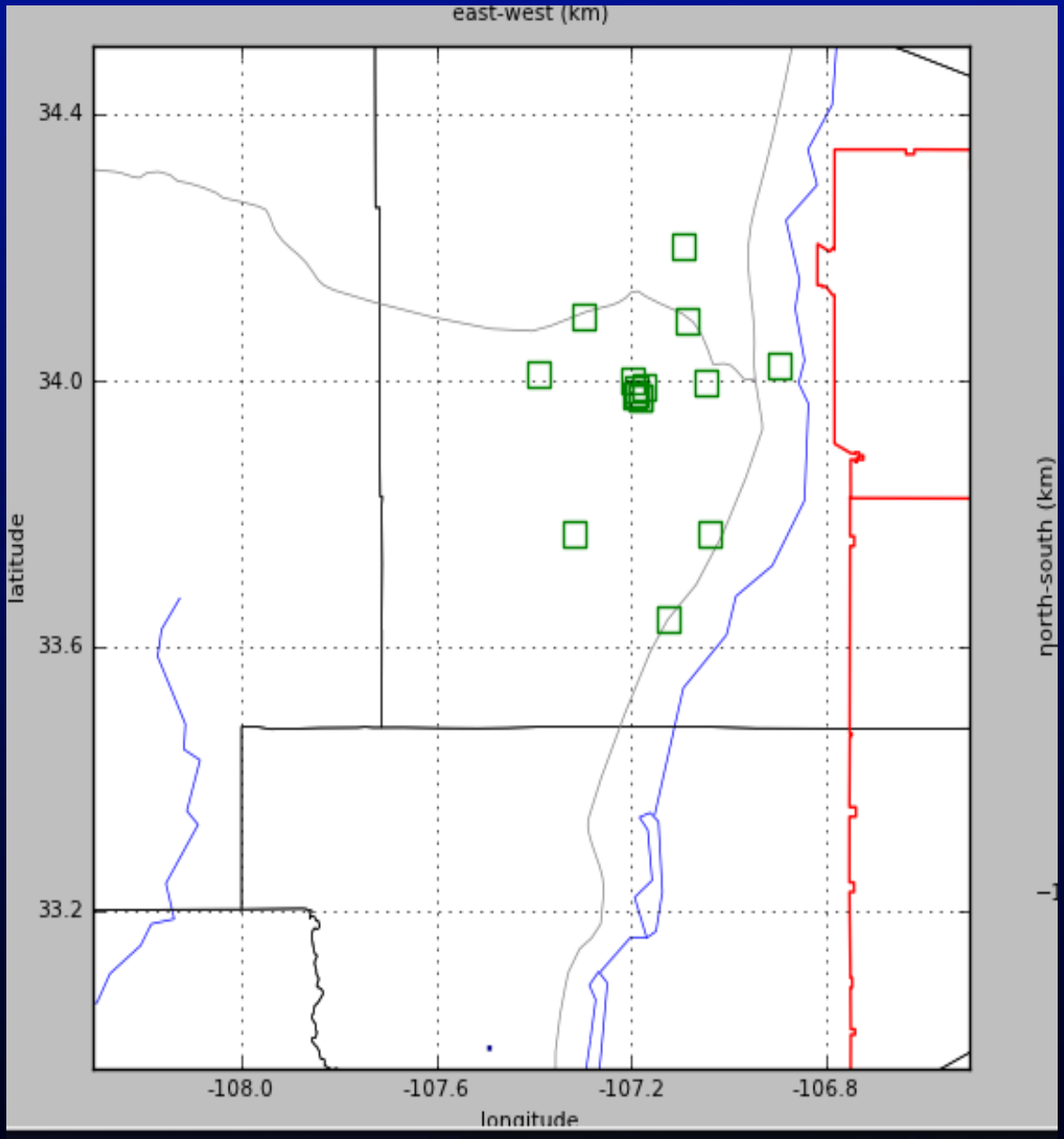


LMA stations 'listen' on a locally unused TV channel (e.g., Ch. 3)

Total Lightning Observations

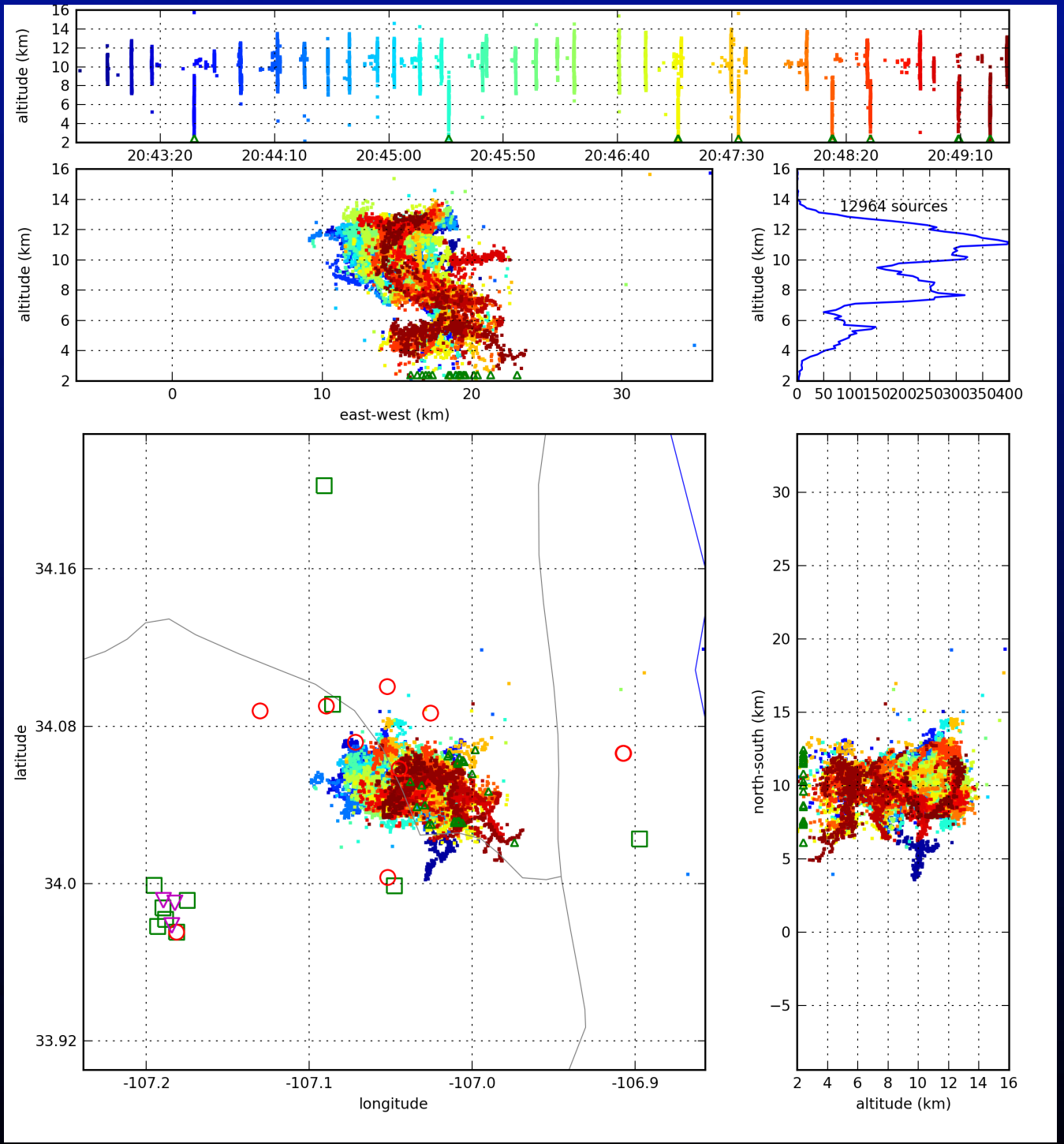


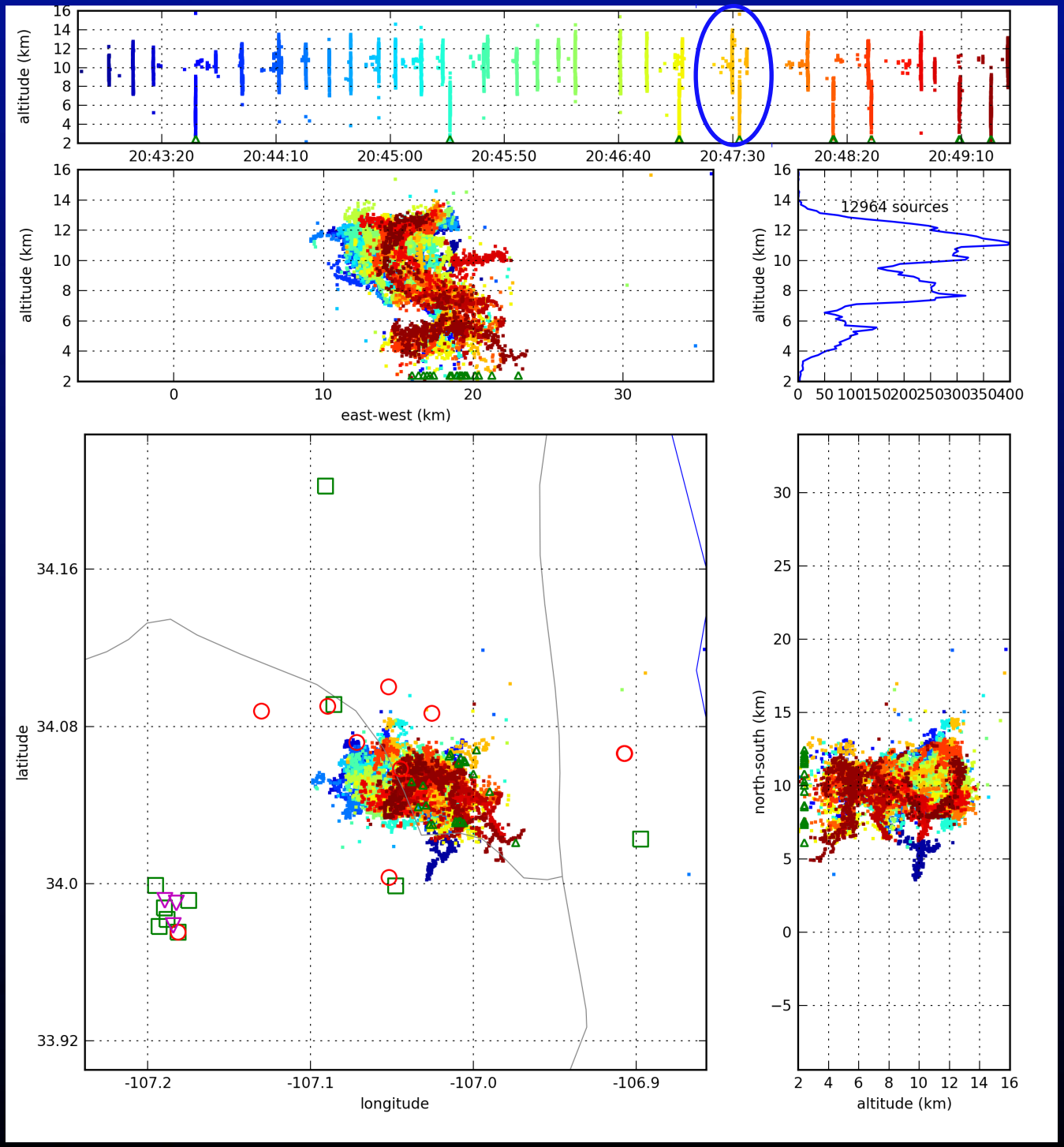

Langmuir LMA
WSMR LMA
Arizona
New Mexico
Albuquerque
Santa Fe
Espanola
Los Alamos
Eldorado at Santa Fe
Gallup
Grants
Flagstaff
Sedona
Camp Verde
Scottsdale
Apache Junction
Sun Lakes
Florence
Coolidge
Casa Grande
Eloy
Casas Adobes
Tucson
Three Points
Vail
Green Valley
Benson
Sells
Sierra Vista
Bisbee
Agua Prieta
Naco
Heroica Nogales
Cananea
Caborca
Altar
Santa Ana
Imuris
Magdalena
Benjamin Hill
Nacozari de García
Globe
Safford
Willcox
Duncan
Silver City
Bayard
Lordsburg
Deming
Las Cruces
Truth or Consequences
Cibola National Forest
Apache National Forest
Gila National Forest
Lincoln National Forest
Carrizozo
Capitan
Ruidoso
Tularosa
Alamogordo
Roswell
Artesia
Carlsbad
Loving
Hobbs
Lovington
Eunice
Jal
Seminole
Andrews
Denver City
Clovis
Portales
Melrose
Fort Sumner
Santa Rosa
Meadow Lake
Logan
Muleshoe
Friona
Dalhart
Grassland
Kermit
Monahans
Pecos
Fort Stockton
Fort Davis
Alpine
Marfa
Marathon
Van Horn
Fort Hancock
Juárez
Socorro
Homestead Meadows South
Puerto Palomas
Ascensión
Nuevo Casas Grandes
Buena Aventura
Miguel Ahumada
Benito Juárez
Café
Nueve Piedras
El Paradero
Tuba City
Pinon
Chinle
Tsaile
Fort Defiance
Ganado
Navajo
Tohatchi
Crownpoint
Zuni Pueblo
Snowflake
St Johns
Show Low
Pinetop-Lakeside
Eagar
Whiteriver
Williams
Prescott
Dewey-Humboldt
Cave Creek
50 mi
100 km

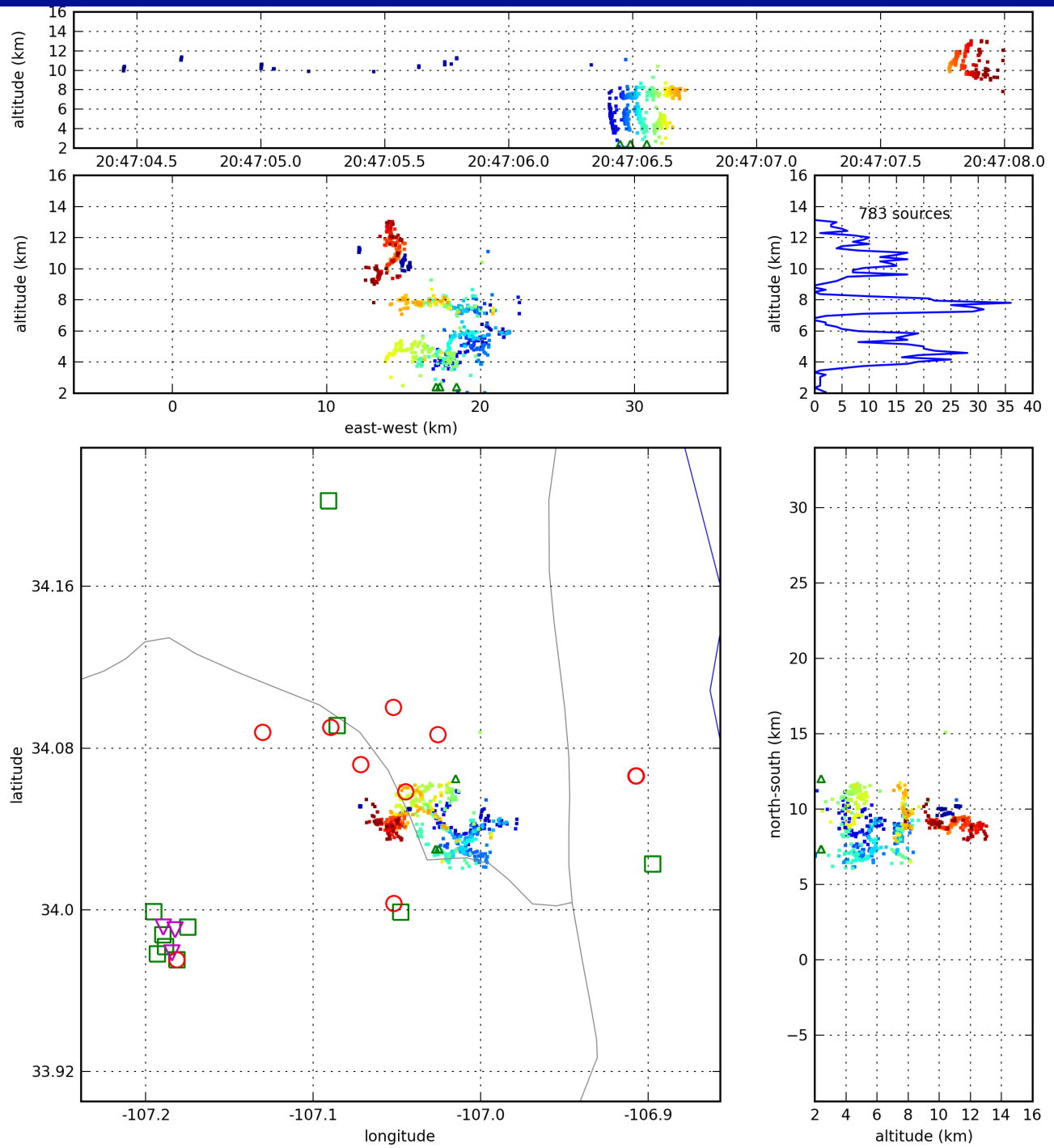


Langmuir Lab LMA

- 16-Station Network
- 10-Station "Normal" LMA
- 6-Station "Compact" LMA
- Most stations solar powered
- Wireless 802.11b Comms
- LiveLMA Display

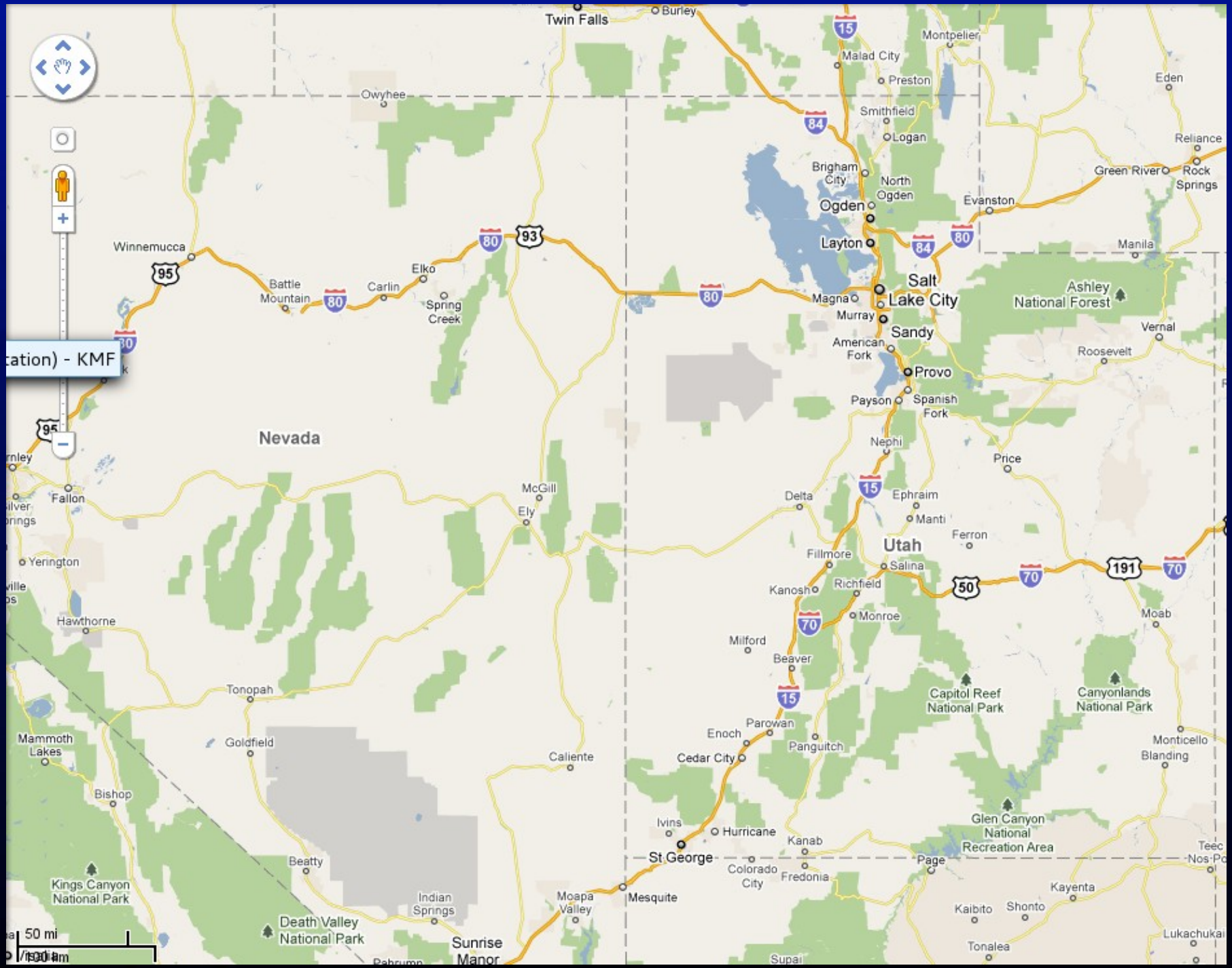

altitude (km)
20:43:20
20:44:10
20:45:00
20:45:50
20:46:40
20:47:30
20:48:20
20:49:10
east-west (km)
12964 sources
latitude
longitude
north-south (km)
altitude (km)


altitude (km)
20:43:20
20:44:10
20:45:00
20:45:50
20:46:40
20:47:30
20:48:20
20:49:10
east-west (km)
12964 sources
latitude
longitude
north-south (km)
altitude (km)


altitude (km)
20:47:04.5
20:47:05.0
20:47:05.5
20:47:06.0
20:47:06.5
20:47:07.0
20:47:07.5
20:47:08.0
east-west (km)
783 sources
latitude
longitude
north-south (km)
altitude (km)

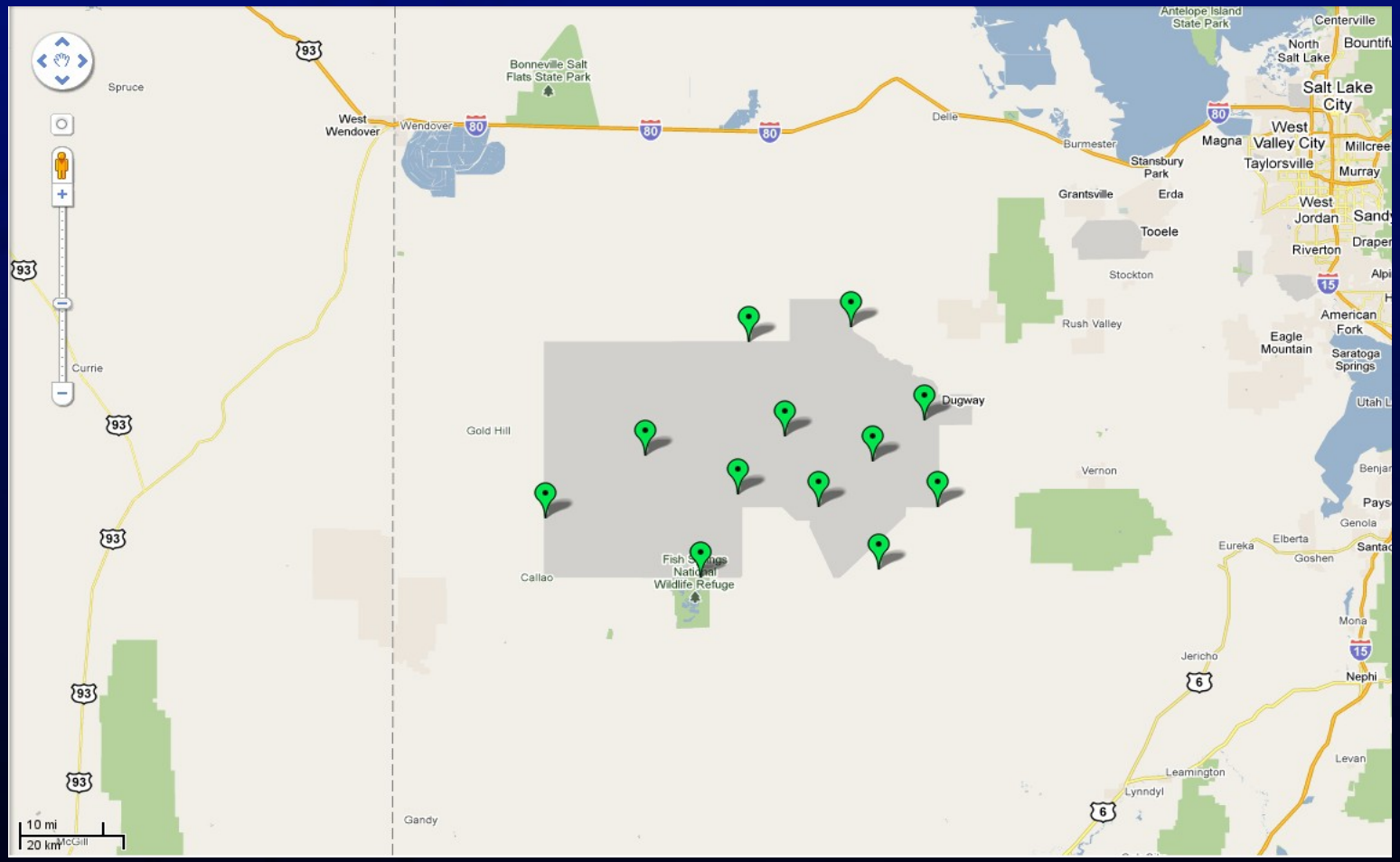
WSMR LMA

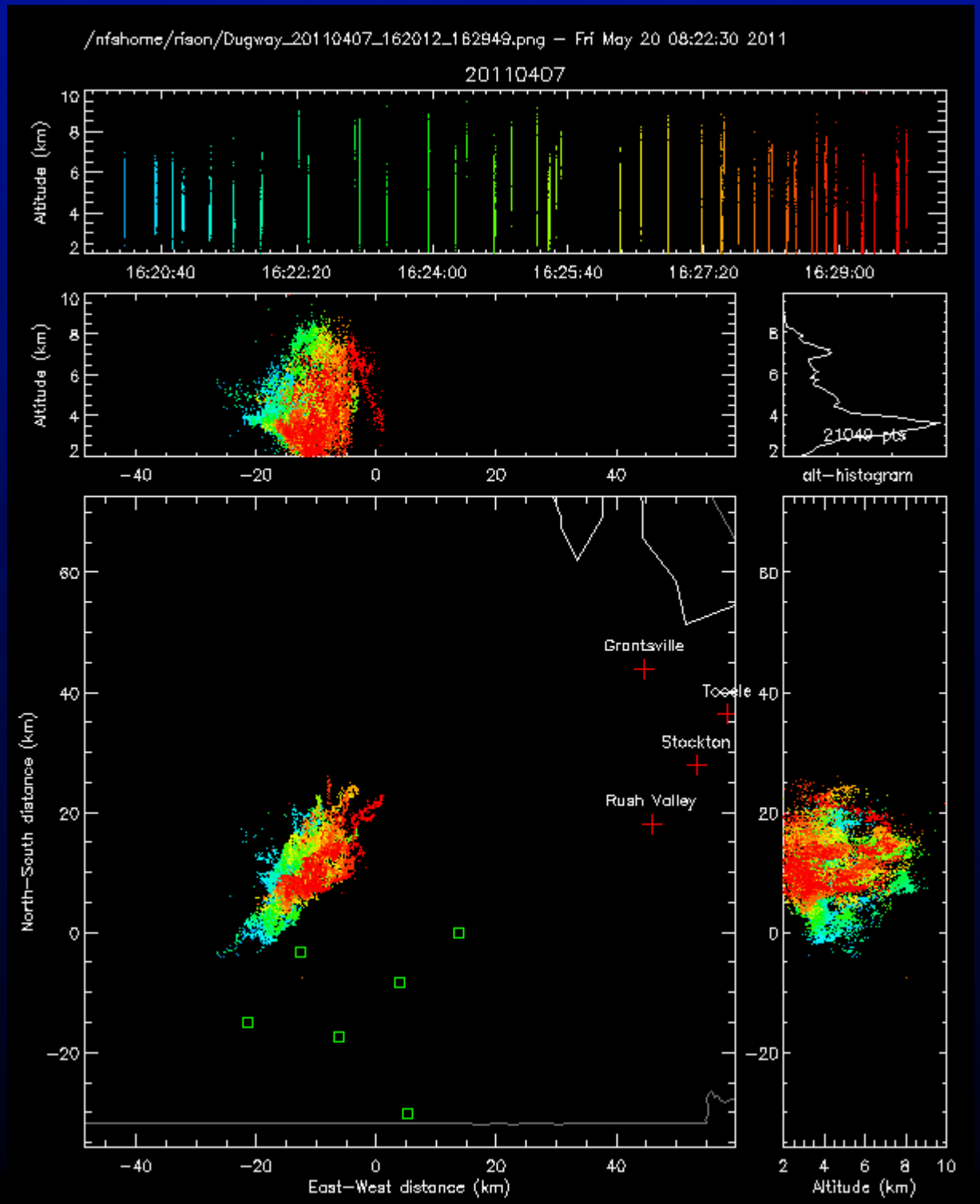
- Installed in 2004
- 12-Station Network (2 more soon)
- AC Powered
- Low-Noise Site
- Fiber Optic Comms

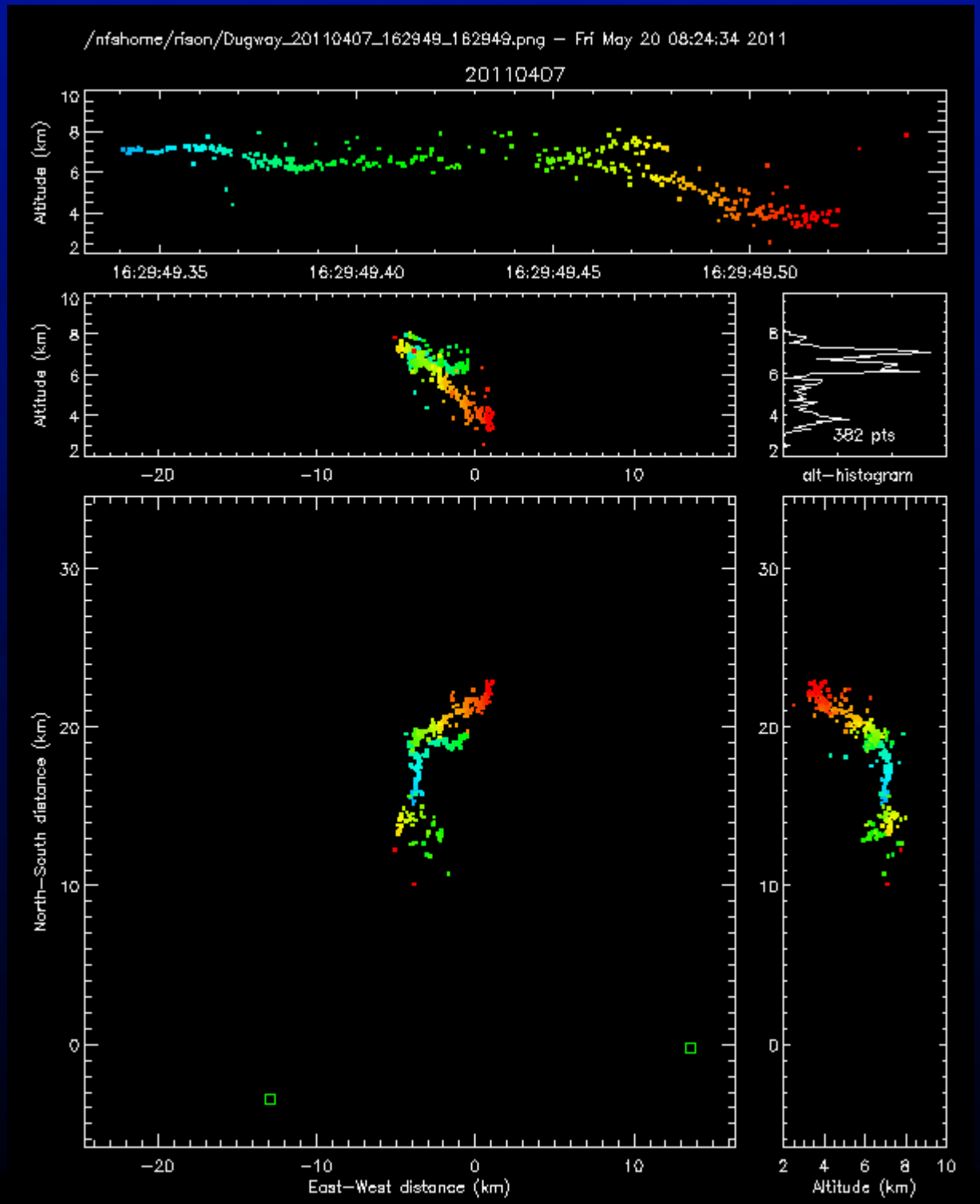

Twin Falls
Burley
Montpelier
Malad City
Preston
Eden
Owyhee
Smithfield
Logan
Reliance
Brigham City
North Ogden
Green River
Rock Springs
Ogden
Evanston
Winnemucca
Layton
Manila
Elko
Battle Mountain
Carlin
Spring Creek
Salt Lake City
Magna
Murray
Ashley National Forest
Sandy
Vernal
American Fork
Roosevelt
Provo
Payson
Spanish Fork
Nevada
Nephi
Price
Fallon
McGill
Ely
Delta
Ephraim
Manti
Ferron
Utah
Fillmore
Salina
Yerington
Kanosh
Richfield
Monroe
Moab
Hawthorne
Milford
Beaver
Tonopah
Capitol Reef National Park
Canyonlands National Park
Mammoth Lakes
Goldfield
Parowan
Enoch
Panguitch
Cedar City
Caliente
Monticello
Blanding
Bishop
Ivins
Hurricane
Glen Canyon National Recreation Area
Kanab
St George
Page
Beatty
Colorado City
Fredonia
Kayenta
Kings Canyon National Park
Indian Springs
Moapa Valley
Mesquite
Kaibito
Shonto
Death Valley National Park
Sunrise Manor
Tonalea
Lukachukai
Supai
50 mi

Dugway Proving Grounds LMA

- 12 Station Network
- Solar Powered
- Very Noise Network
- Limited Comms




/nfshome/rison/Dugway_20110407_162012_162949.png – Fri May 20 08:22:30 2011
20110407
Altitude (km)
16:20:40
16:22:20
16:24:00
16:25:40
16:27:20
16:29:00
21049 pts
alt–histogram
Grantsville
Tooele
Stockton
Rush Valley
North–South distance (km)
East–West distance (km)
Altitude (km)


/nfshome/rison/Dugway_20110407_162949_162949.png – Fri May 20 08:24:34 2011
20110407
Altitude (km)
16:29:49.35
16:29:49.40
16:29:49.45
16:29:49.50
382 pts
alt–histogram
North–South distance (km)
East–West distance (km)
Altitude (km)

DC3 LMA (Deep Convective Clouds & Chemistry Experiment)

- 16-Station Network in Northeastern Colorado, Spring 2012
- Solar Powered
- Cell Phone Modem Comms
- Transition to Colorado Front Range LMA after DC3 Project