

Physics 535 – Lecture 7

Physics of Lightning

The Case for Blunt Lightning Rods

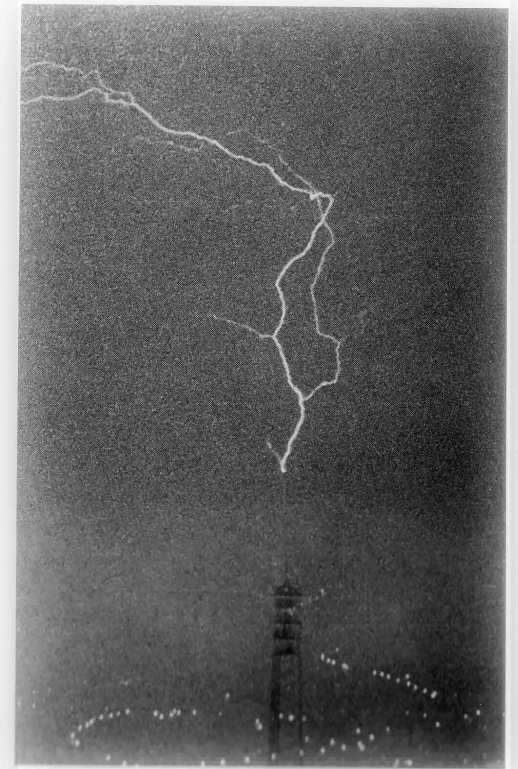
2/3/16

Richard Sonnenfeld

**Physics Department &
Langmuir Laboratory for Atmospheric Physics
New Mexico Institute of Mining and Technology**

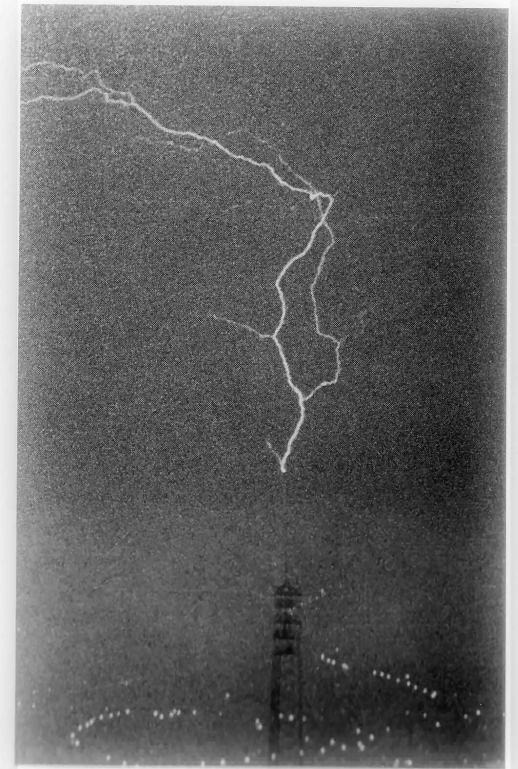
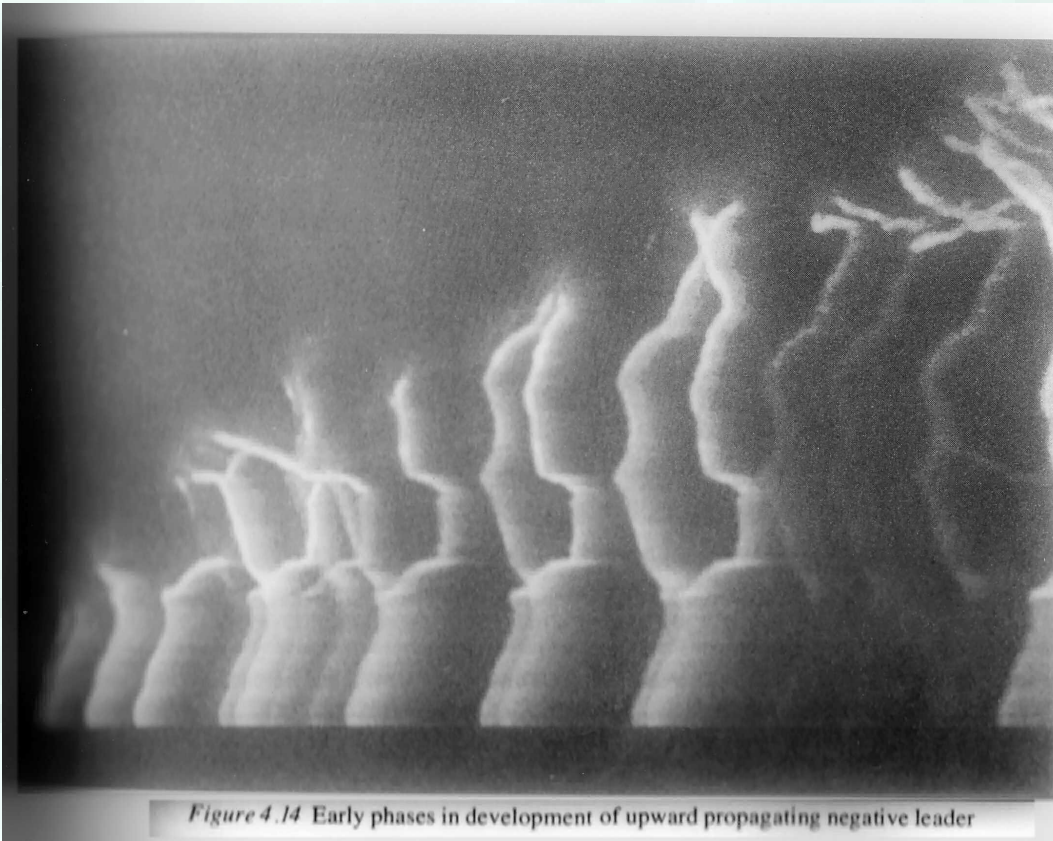
(Photo courtesy of Harald Edens)

Lightning Launched Upward from Structures



From: L. Salanave, “Lightning and Its Spectrum”, Univ. of Arizona Press, (1980).

Lightning Launched Upward from Structures

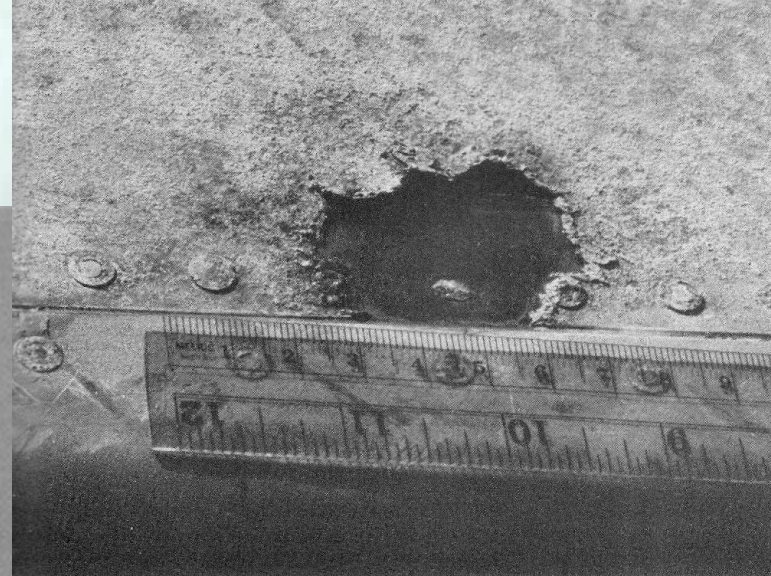
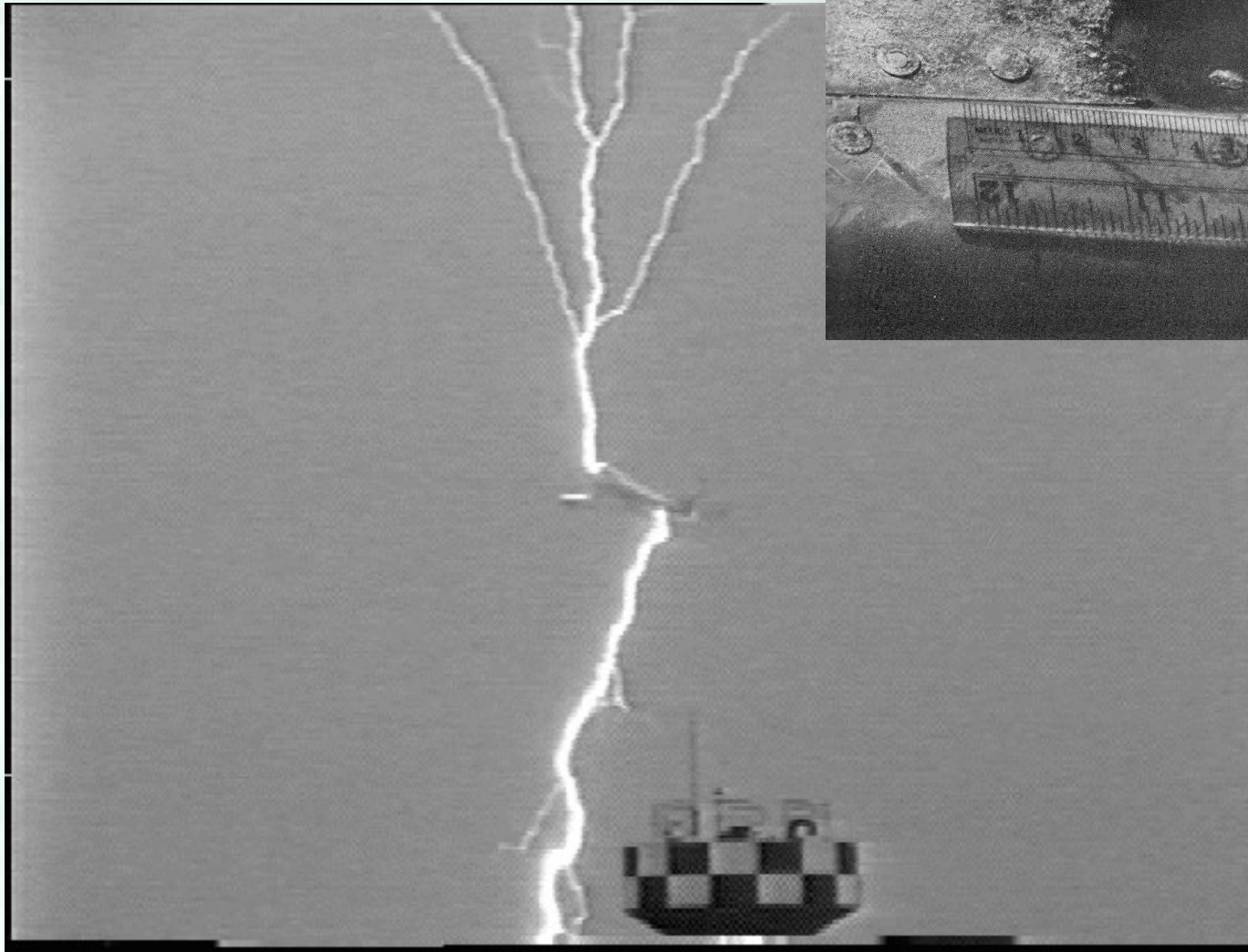


From: L. Salanave, “Lightning and Its Spectrum”, Univ. of Arizona Press, (1980).

Triggered Lightning (Unintentional)



Aircraft at Kamatsu Air Force Base (Courtesy of Prof. Zen Kawasaki).



Commercial aircraft at Kamatsu Air Force Base (Courtesy of Prof. Zen Kawasaki).

Outline

Why study lightning?

What do we know?

How a lightning flash develops.

Streamers, leaders, attachment and lightning rods.

Lightning Vocabulary

Triggered lightning

Lightning and convection / Energy source for lightning

Charging Mechanisms

Charge Structure of clouds

Lightning Mapping Array

Operational Meteorology and Climatology

Lightning and convection

LMA and severe storms

Space studies (LIS, OTD, GLM).

Offer small zone of protection
(20 m radius rolling sphere—
See NFPA 780).

Are preferentially hit if
launch upward leader.

Provide a highly conductive
path to ground.

Do NOT discharge the
clouds.

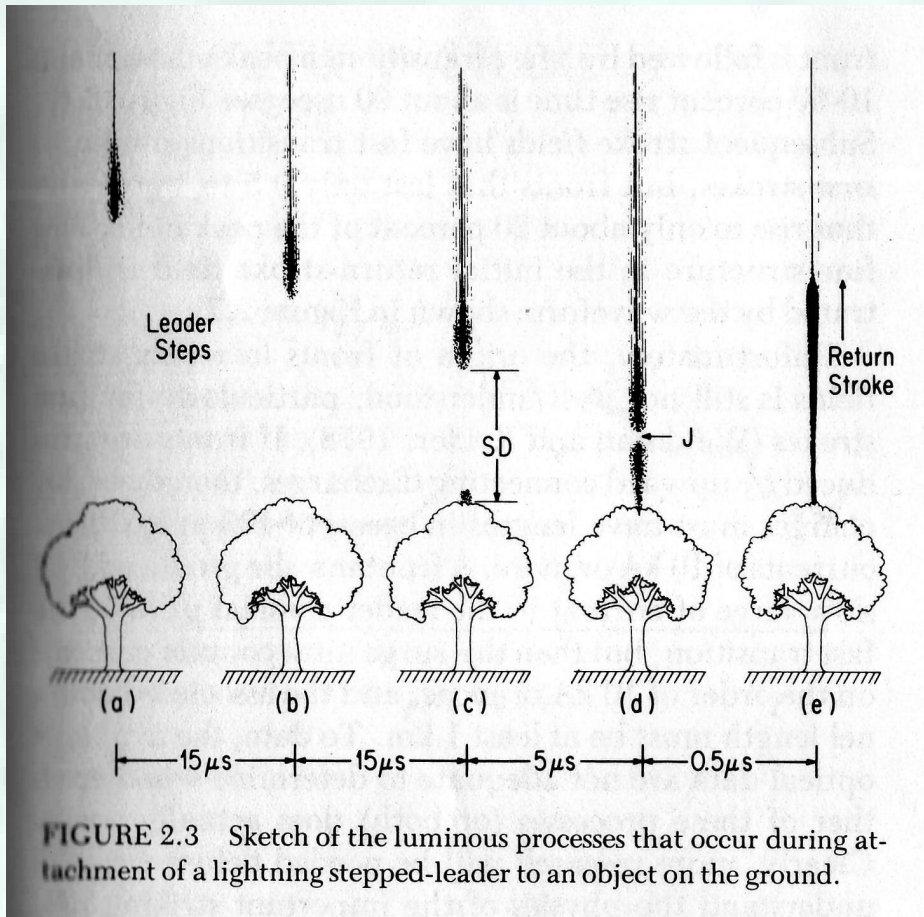
No “Breakthrough” lightning
rod has been shown to protect
large areas

Lightning Rods

(Air terminals)



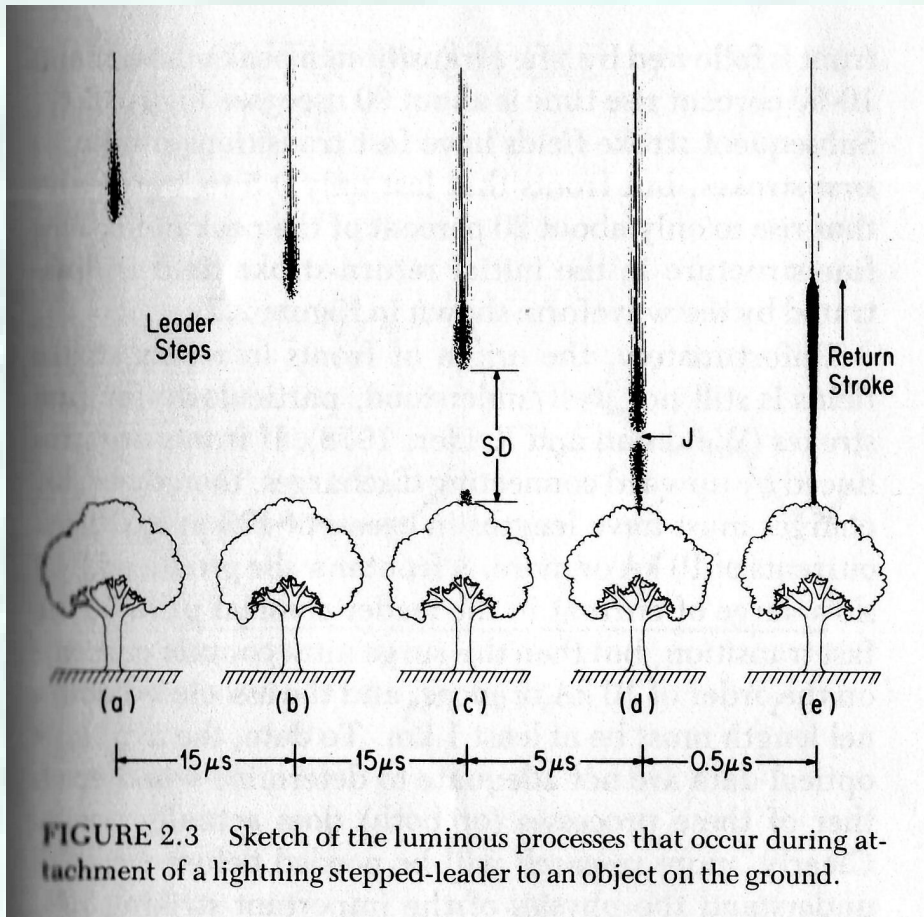
Lightning Connection Process



From: P. Krider, “Physics of Lightning”,
National Academy Press, (1986).

From: Rakov and Uman, “Lightning: Physics
and Effects”, Cambridge U. Presse, (2003).

Lightning Connection Process



From: P. Krider, "Physics of Lightning",
National Academy Press, (1986).

Photo Copyright
Kevin Ambrose
www.weatherbook.com

Argument

Corona occurs at lower fields on a sharp rod (100 kV/m vs 250 kV/m).

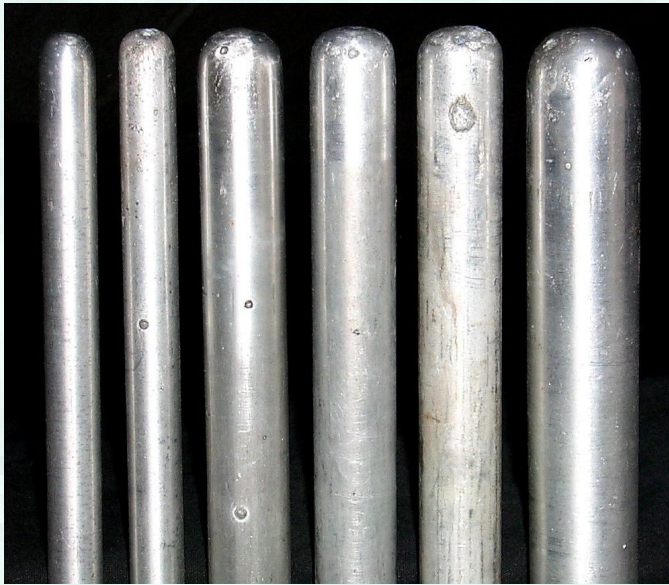
Corona frequency is higher on a sharp rod (50 kHz ... 500 Hz).

Charge/pulse is lower on a sharp rod

The sharp rod is masked by its own ions during the critical microseconds when the leader is making its “final decision” about where to attach.

($3E5$ m/s ... 30 meters in 100 us)

Blunt vs. Sharp Rods



Rods set up in pairs
separated by 5.3 meters.

Fuses indicated hits.

13 blunt rods hit. (12.5-25
mm)

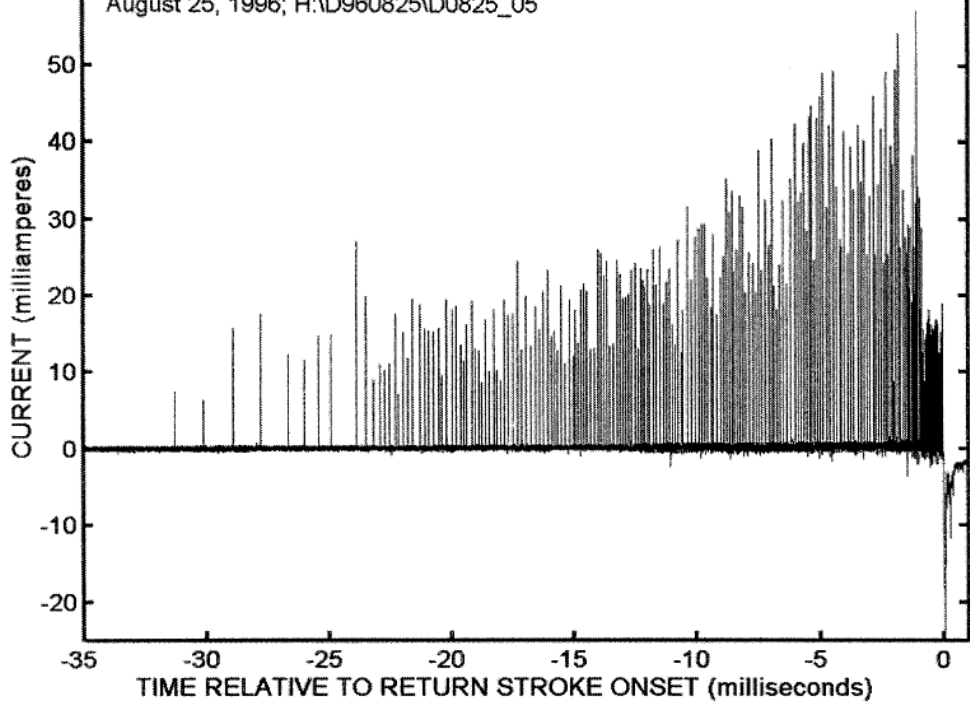
No sharp rods hit.

No “very blunt” rods hit.

From Moore et. al, “Lightning Rod
Improvement Studies” JAM, 39, (2000)

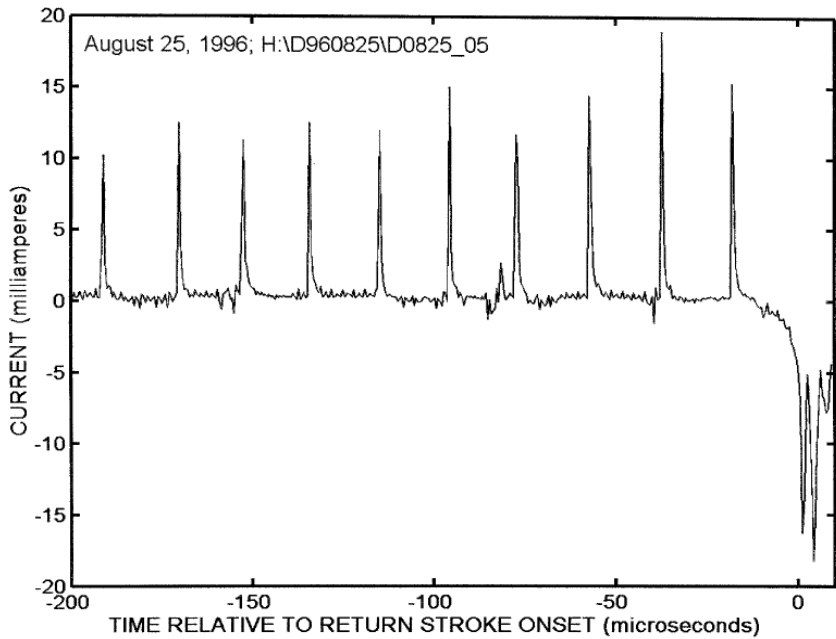
R. Sonnenfeld, Langmuir Lab & NM Tech Physics (Jan 2016)

Free for Educational Use with Attribution



Sharp Rod

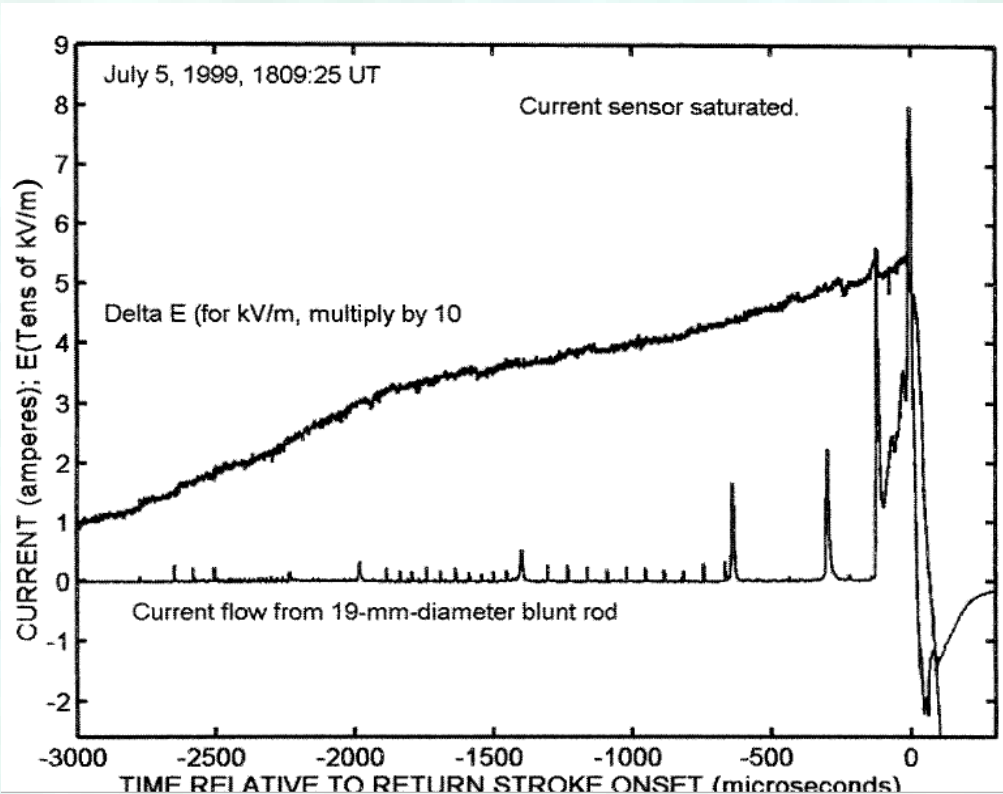
Flash strikes nearby



Zoom

Blunt Rod

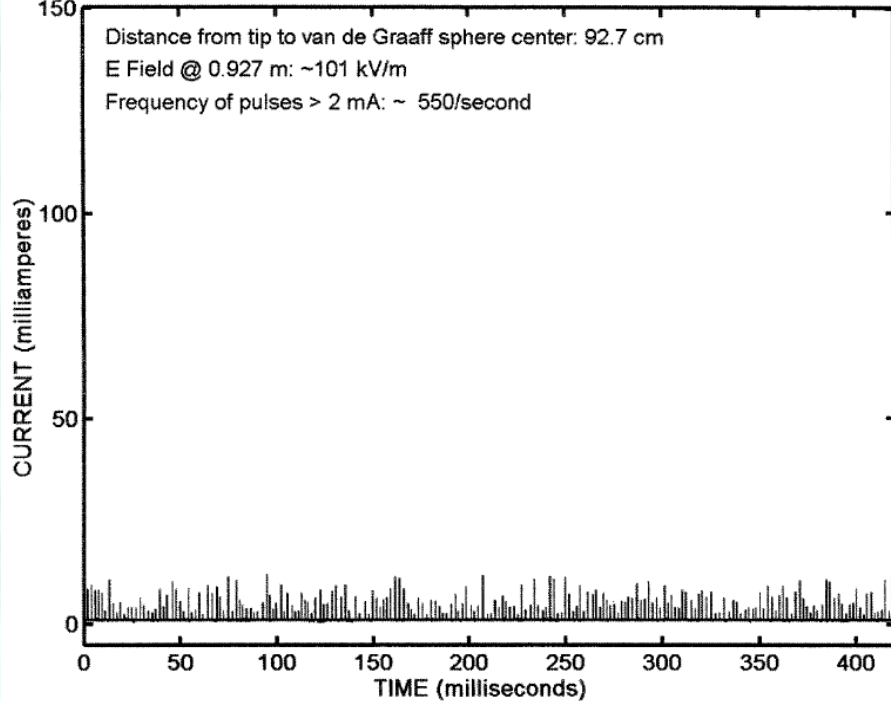
Stroke connects 40 m away



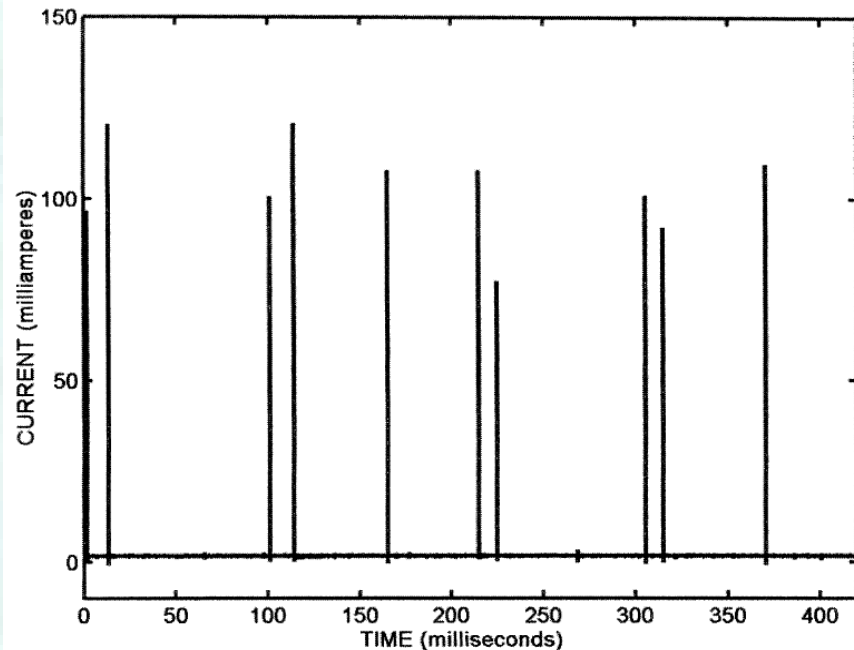
Note sustained high current burst.

Sharp Rod

Van de Graaf ... 100 kV/m
(Current vs. time)

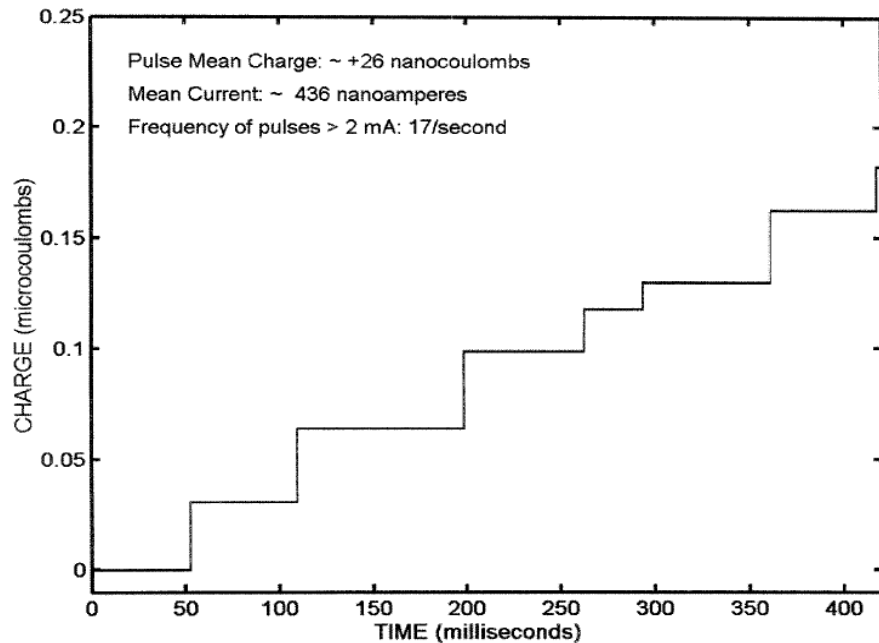
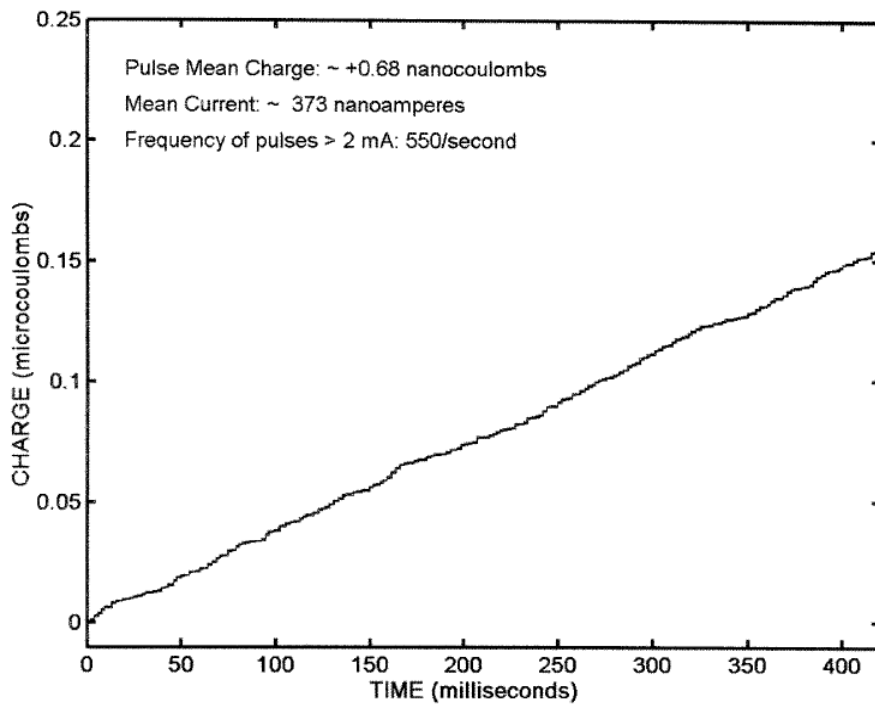


Blunt Rod



Sharp Rod

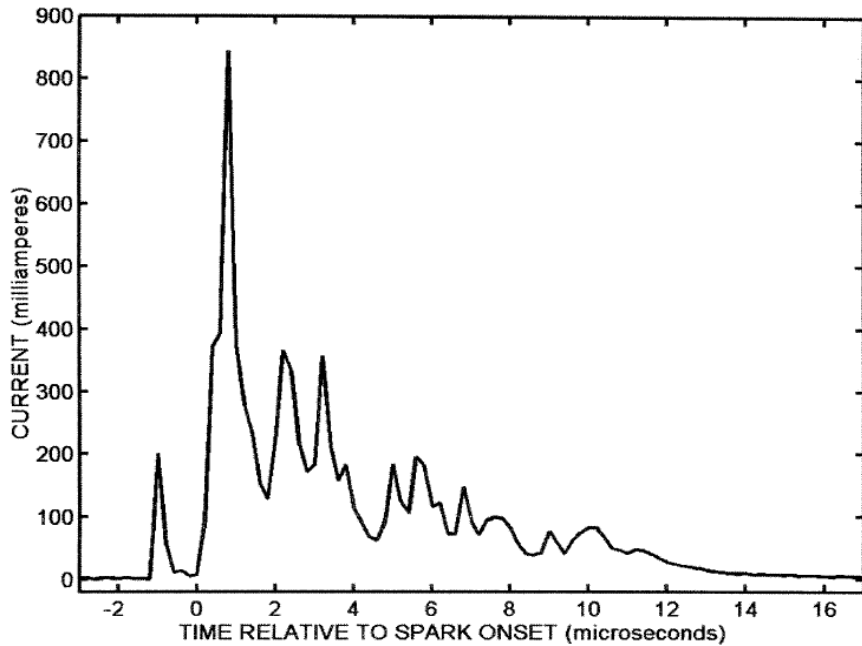
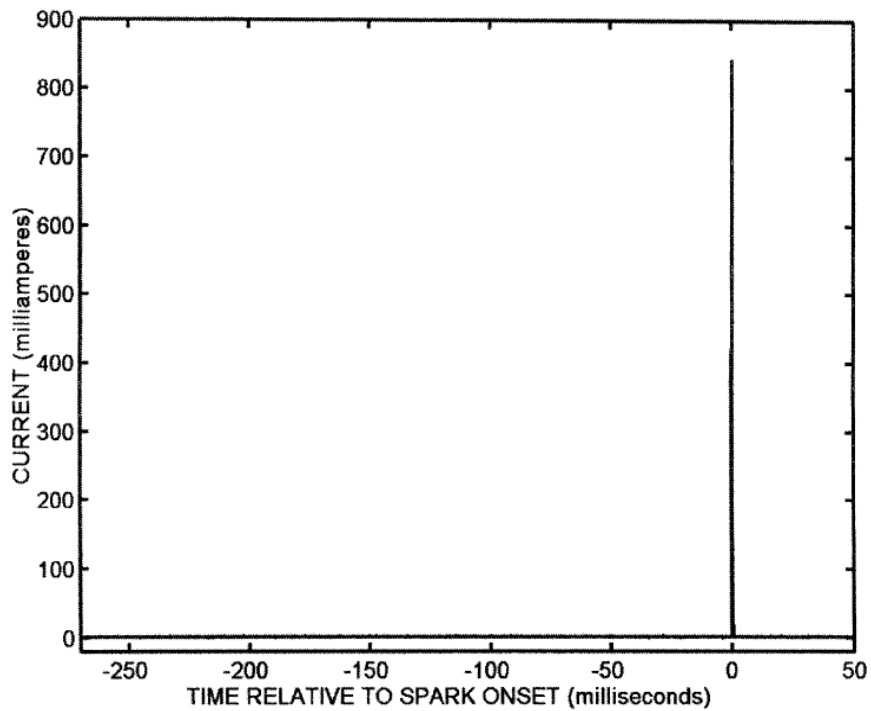
Van de Graaf ... 100 kV/m
(Charge vs. time)



Blunt Rod

Blunt Rod

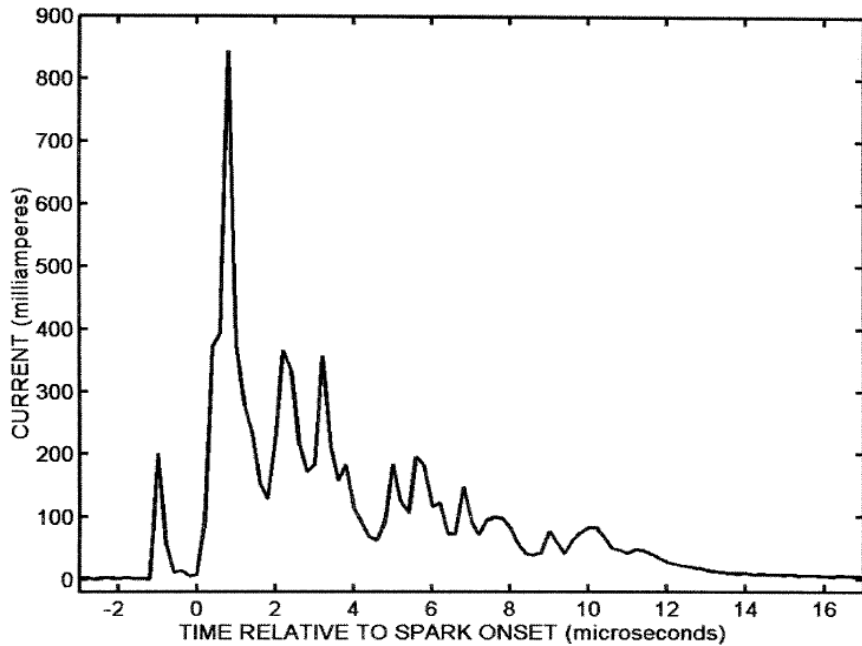
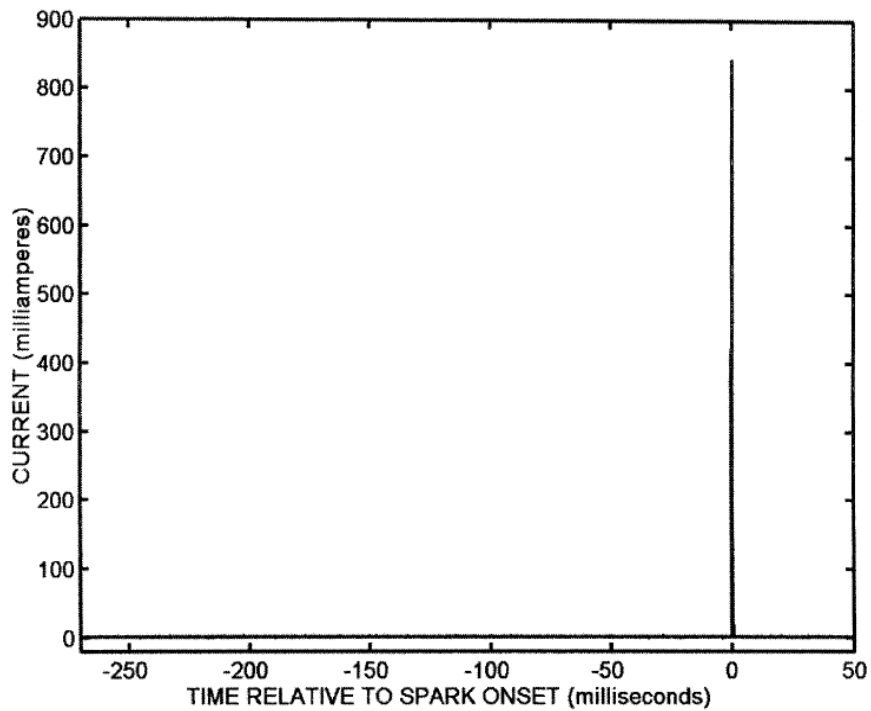
Van de Graaf ... 250 kV/m
(Current vs. time)



Zoom

Blunt Rod

Van de Graaf ... 250 kV/m
(Current vs. time)



Zoom

Argument

Corona occurs at lower fields on a sharp rod (100 kV/m vs 250 kV/m).

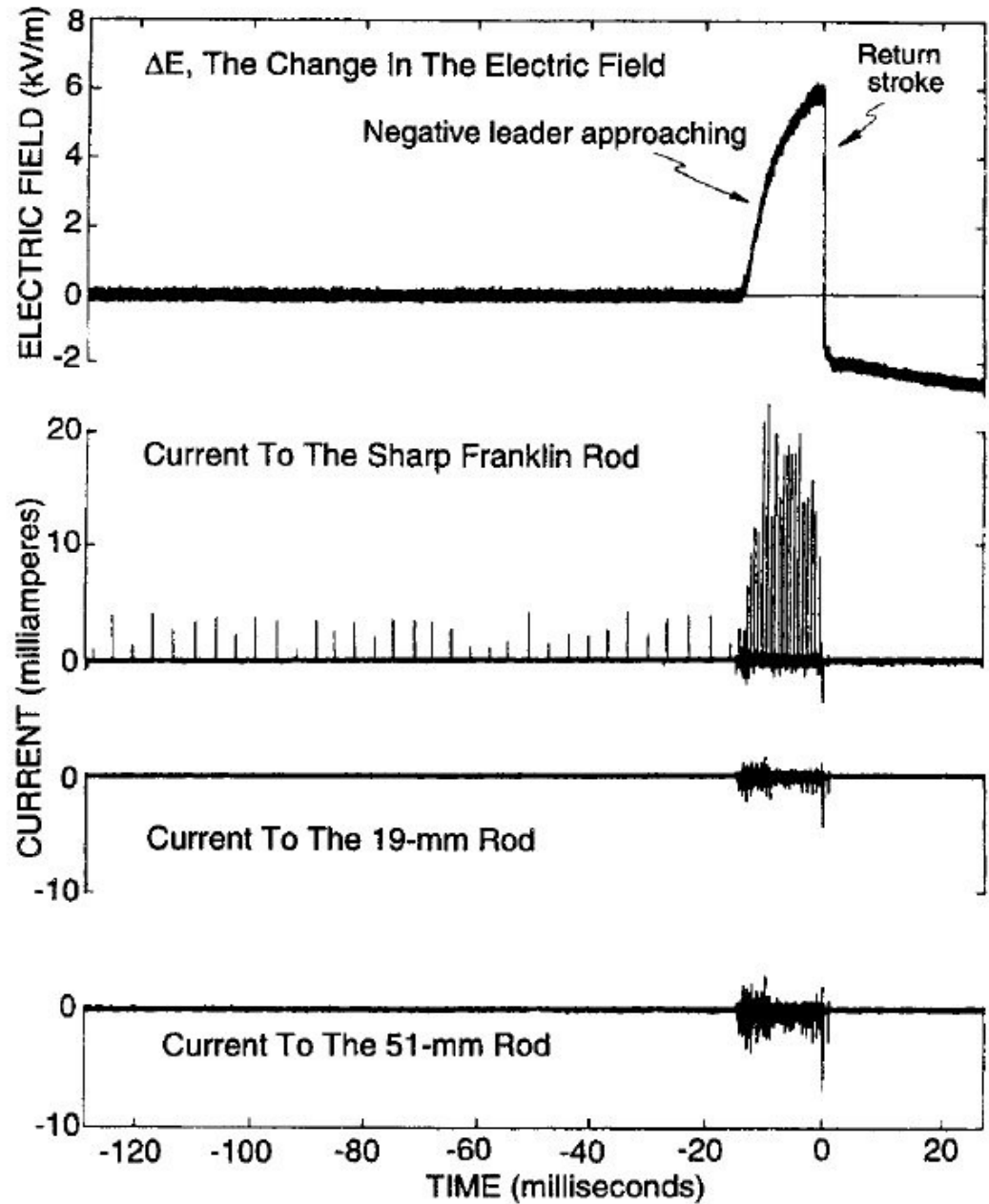
Corona frequency is higher on a sharp rod (50 kHz ... 500 Hz).

Charge/pulse is lower on a sharp rod

The sharp rod is masked by its own ions during the critical microseconds when the leader is making its “final decision” about where to attach.

($3E5$ m/s ... 30 meters in 100 us)

Blunt vs. Sharp Rods



From Moore et. al, "Lightning Rod Improvement Studies" JAM, 39, (2000)