Het bliksemt en knettert

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Ontladingen, interessant en gevaarlijk ?

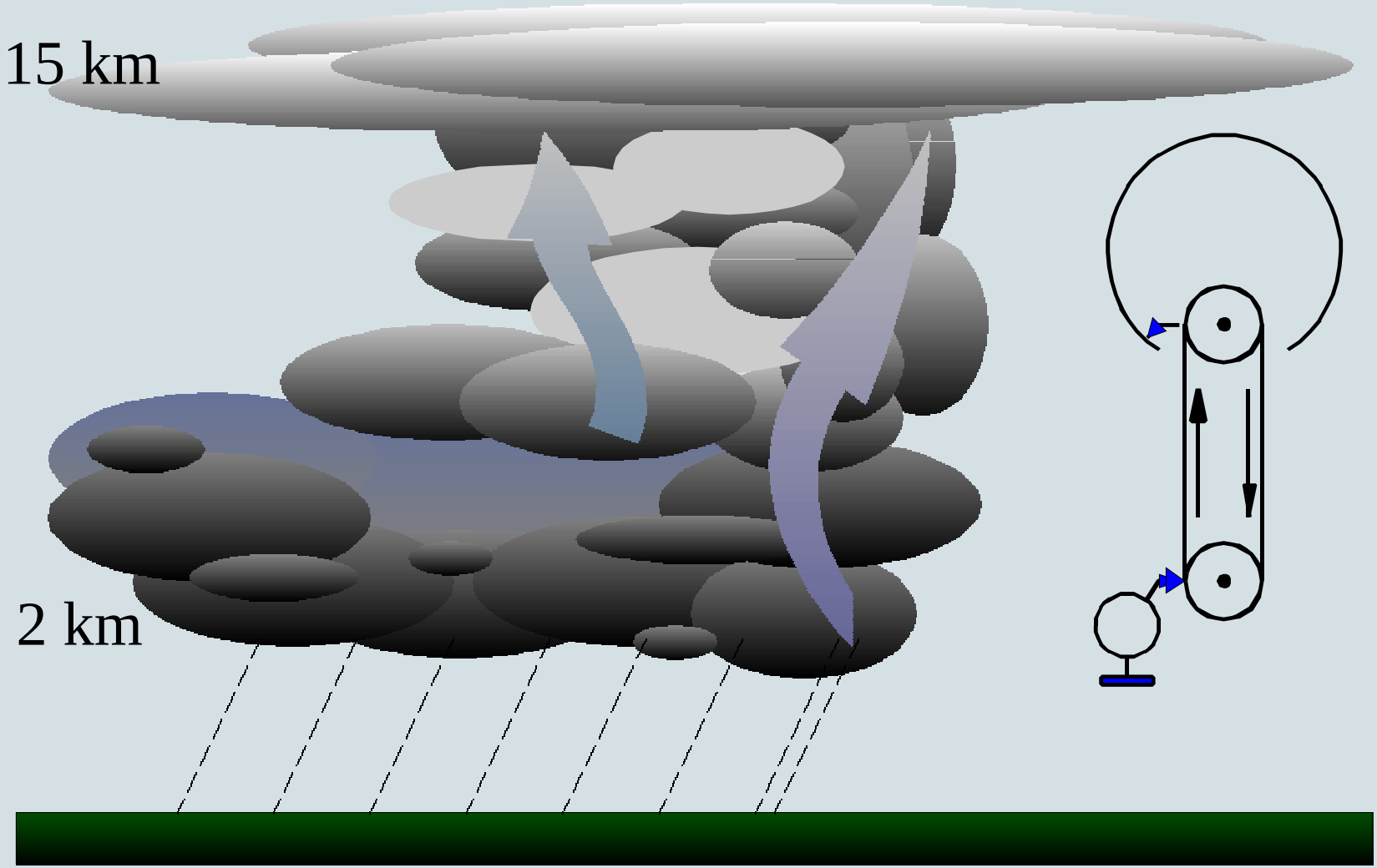
1. Bliksem en wat we niet zien of horen.
2. Corona
3. ESD

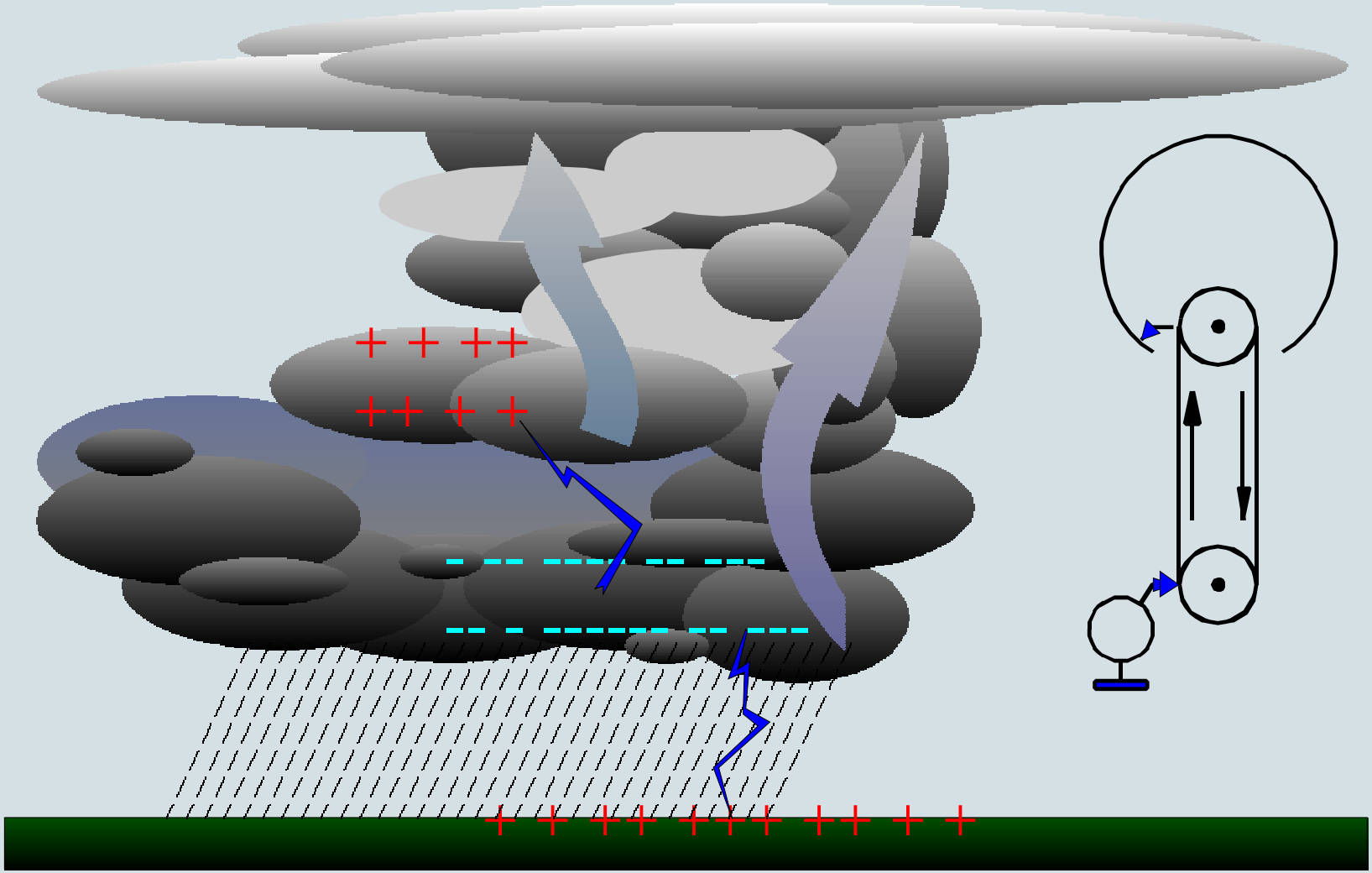
Bliksem, klassiek beeld

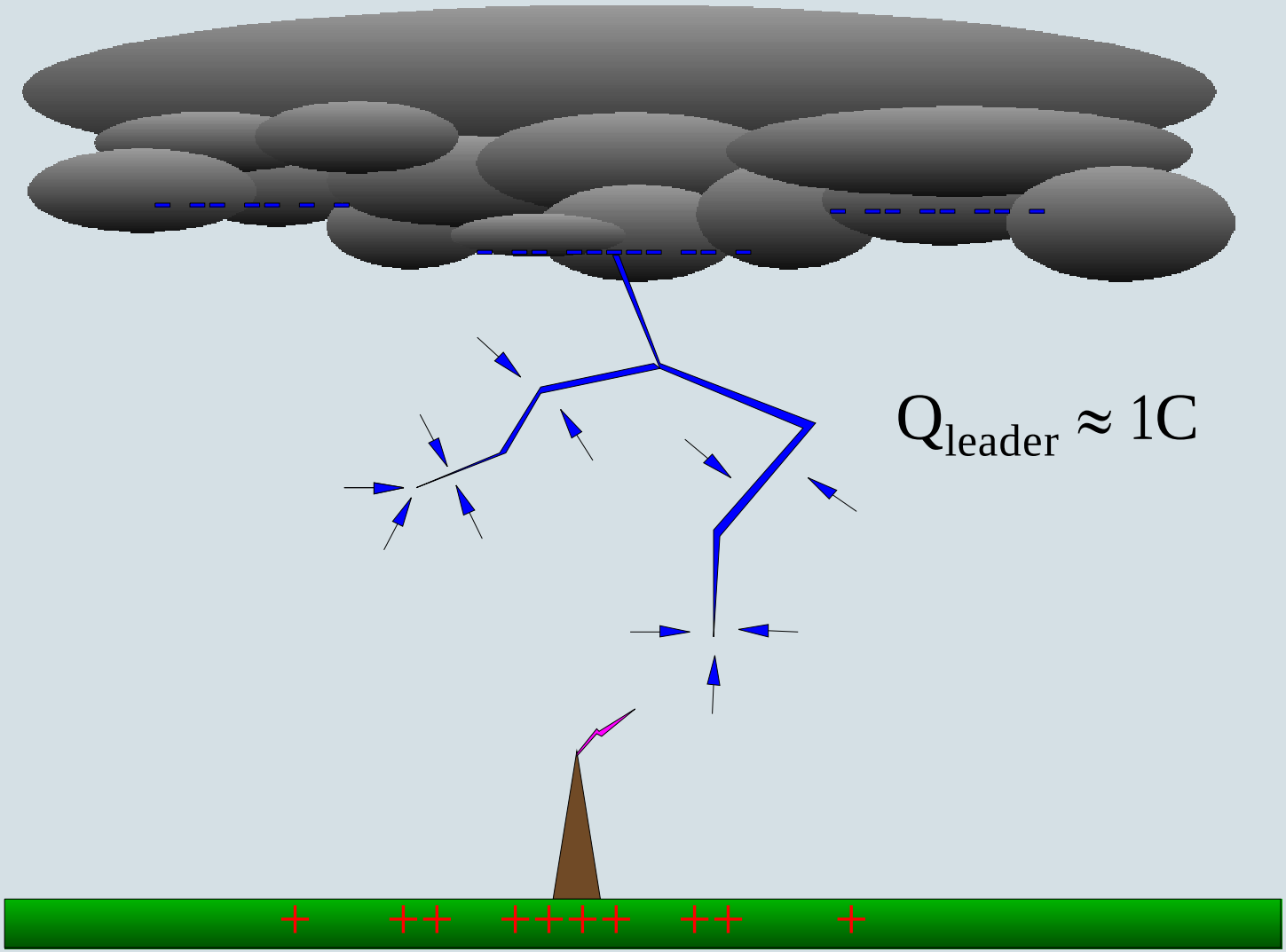
Ladingsopbouw traag, convectie

Ontlading met grote stroom: 100 kA

Kort (10 - 300 μs) en langere (0.5 s) duur


15 km
2 km




$Q_{leader} \approx 1C$


"The Hit" ©1993 Niagara Mohawk Power Corporation

C T R Wilson 1924
Proc. Phys. Soc. London 37 32D-37D

Wat is er boven de wolken?

Abstract. A thundercloud is an electric generator in which the separation of positive and negative charges occurs at a rate corresponding to a current which may amount to some amperes; the potential difference between its poles may reach values of the order of a million kilovolts. Attention is drawn to three effects of the electric field of thunderclouds or shower clouds (all of which may occur even when there is no thunder). (1) The electric field of the cloud may cause ionization at great heights, the result being continuous or discontinuous discharge between the cloud and the upper atmosphere. (2) Discharge from pointed earthed conductors is likely to constitute an important part of the current between the ground and the base of a thundercloud, and the resulting ionization near the ground may be large. (3) By its accelerating action on particles the electric field of a thundercloud may produce extremely penetrating corpuscular radiation.

Parameters

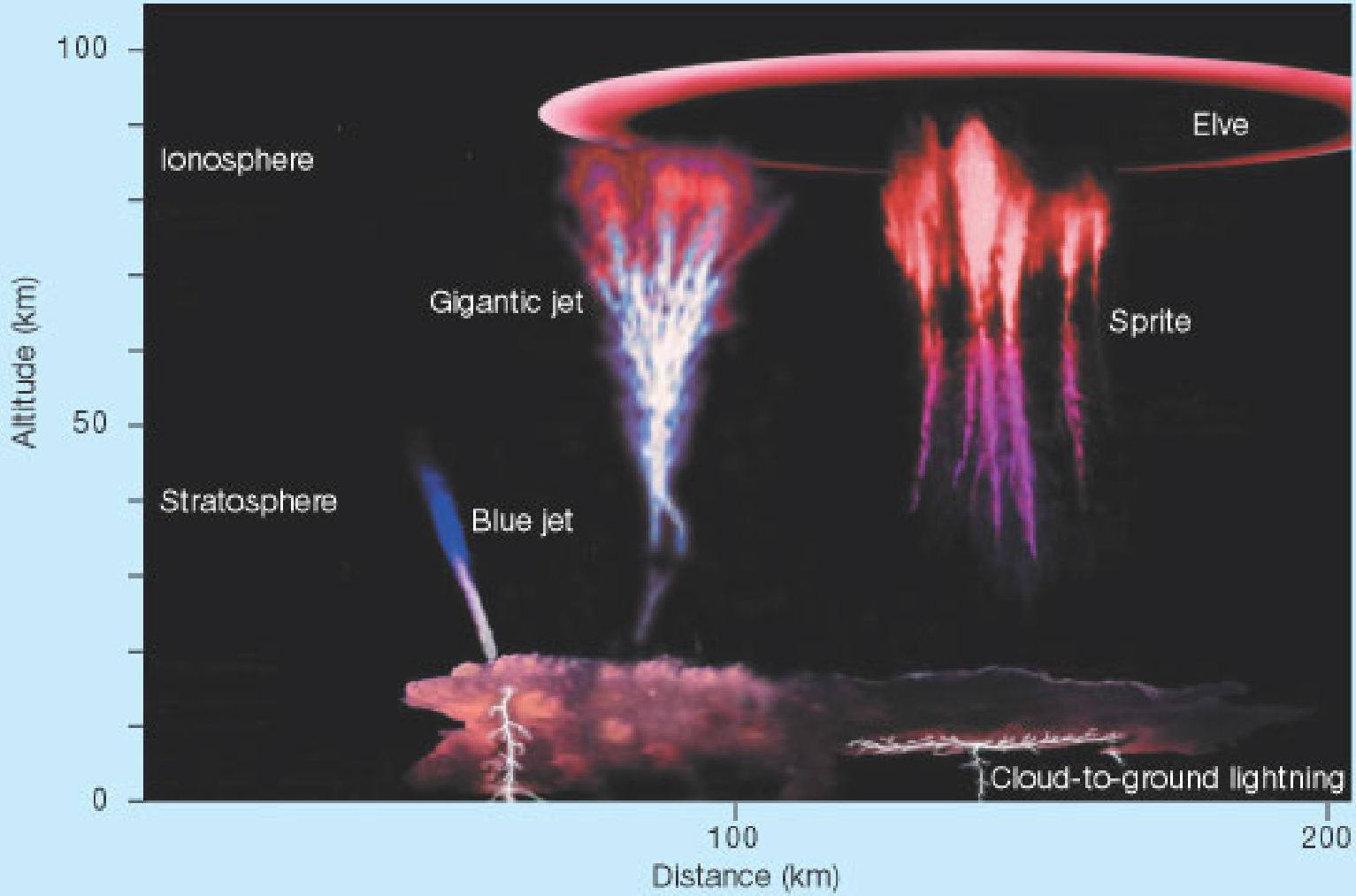
- Gebied tussen tropo en ionosfeer: Ignorosfeer
- Dichtheid lucht lager, tot 10^{-5} gronddruk
- Low light conditie nodig

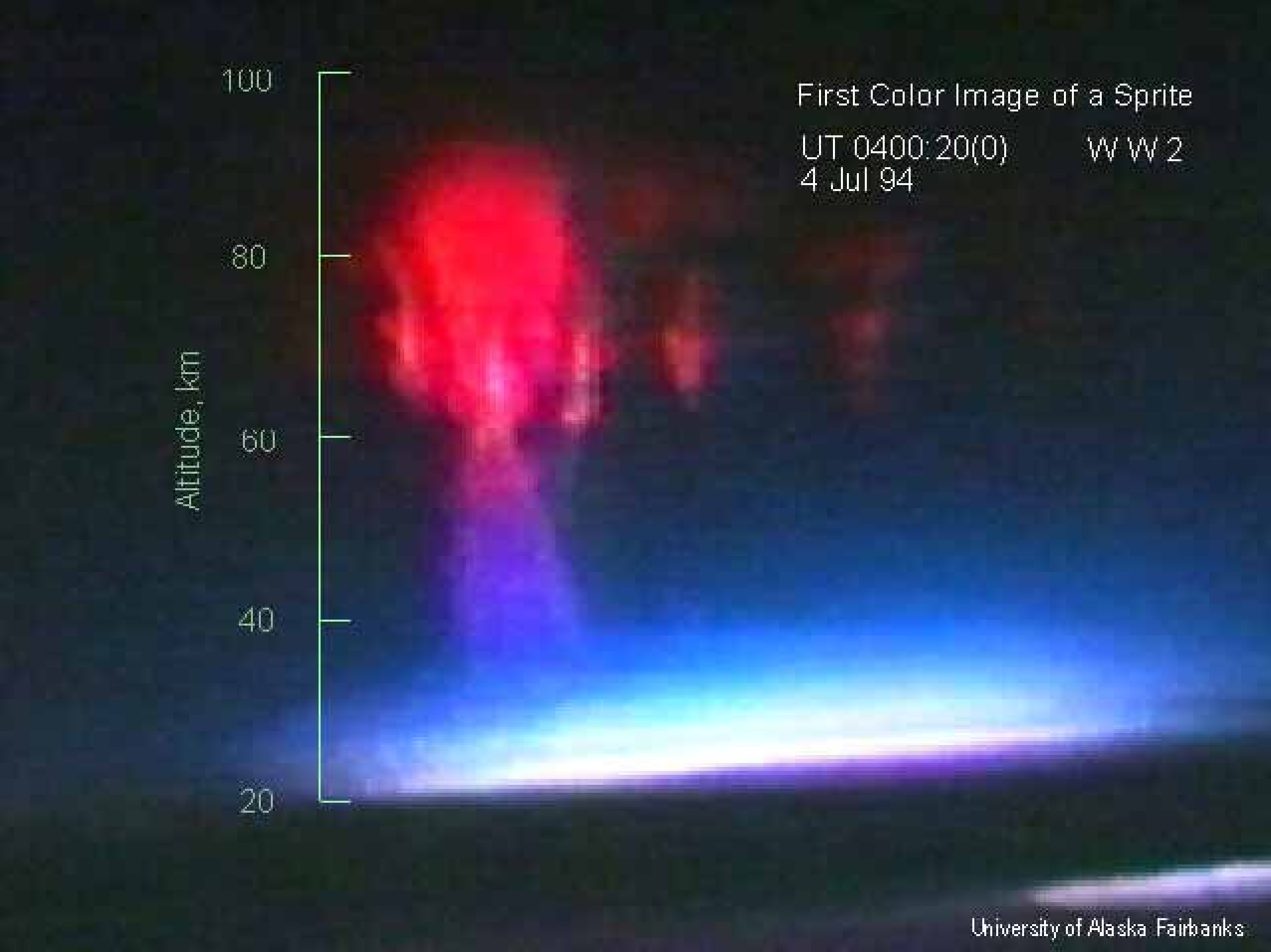
Atmospheric physics: Electric jets
Victor P. Pasko
Nature 423, 927-929 (26 June 2003)

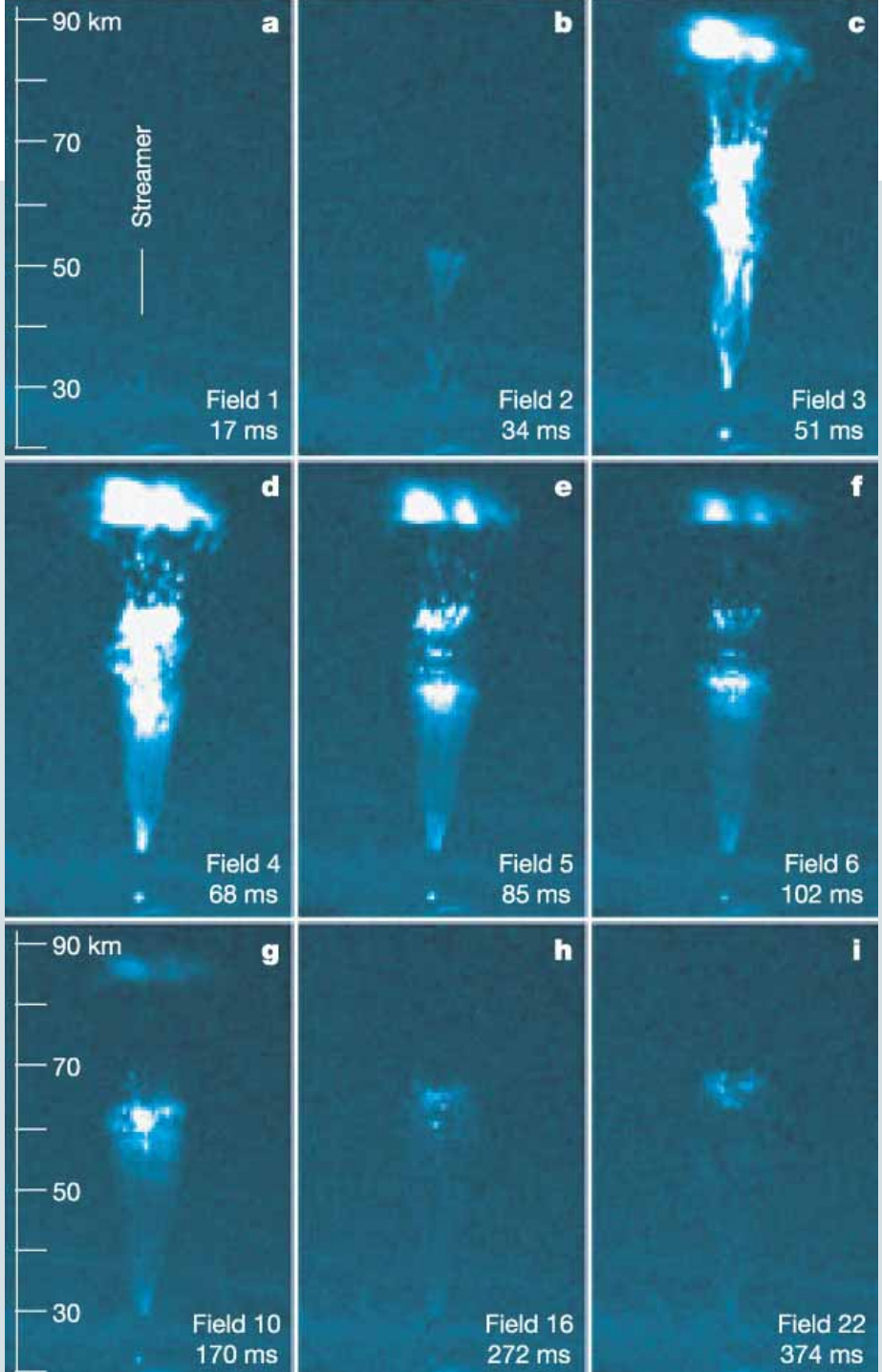
“.. discharge between the cloud and the upper atmosphere ..”

Powerful electric currents have been detected in discharges between thunderclouds and the upper atmosphere. Carried by gigantic jets, they are a new factor in the model of the Earth's electrical and chemical environment. Although cloud-to-ground lightning is a familiar disruption in the modern electronic world, lightning formed above the clouds is also an important factor in what is known as the global circuit of atmospheric electricity. Radio atmospherics are natural electromagnetic emissions from lightning discharges and can propagate thousands of kilometres through the 'waveguide' formed by the Earth's surface and the ionized region of the upper atmosphere, known as the ionosphere.

Atmospheric physics: Electric jets
Victor P. Pasko
Nature 423, 927-929 (26 June 2003)




First Color Image of a Sprite
UT 0400:20(0)
4 Jul 94
W W 2
100
80
60
40
20
Altitude, km
University of Alaska Fairbanks



H. T. Su et al.
Nature 423 (2003) 974-976

Duration 0.65 s after pos. flash.

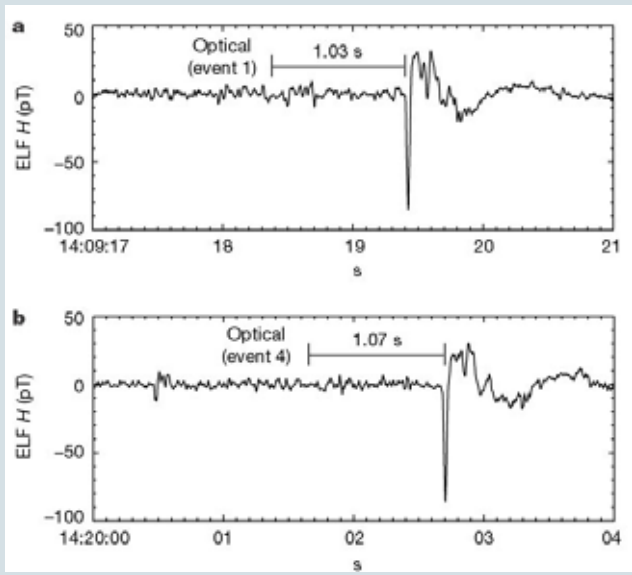
Starts at 18 km, above cloud top

Reaches Ionosphere at 90 km

Combination of blue jet and sprite

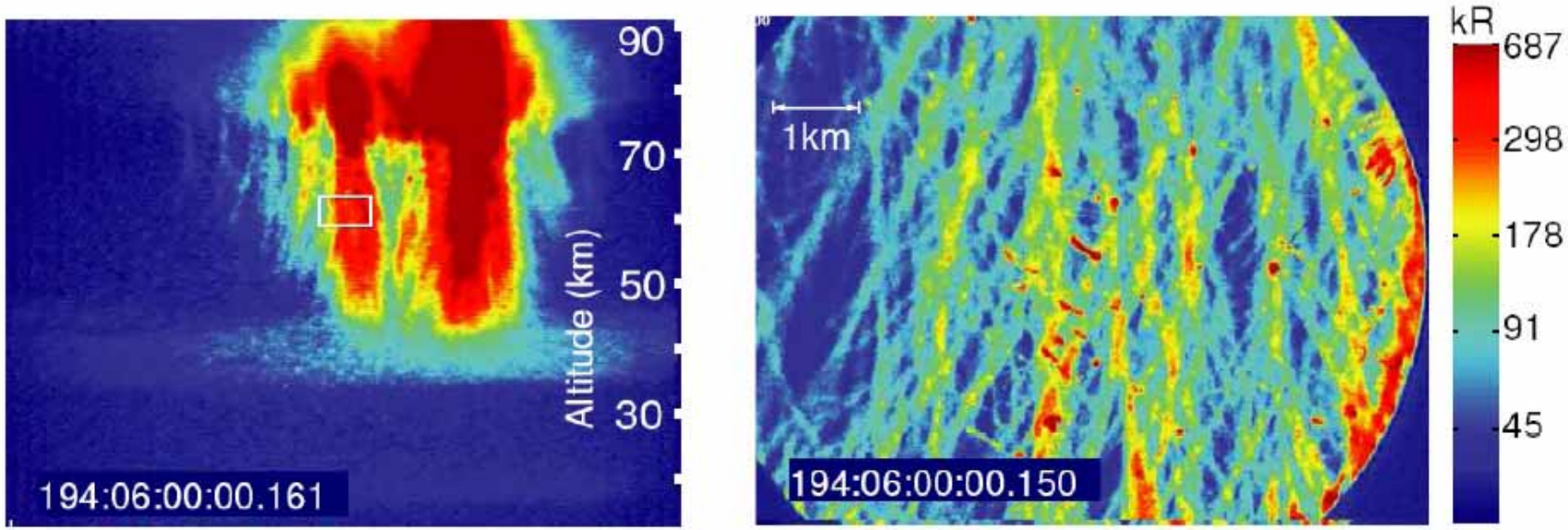
Charge moment 1000 C km

Goes with ELF event



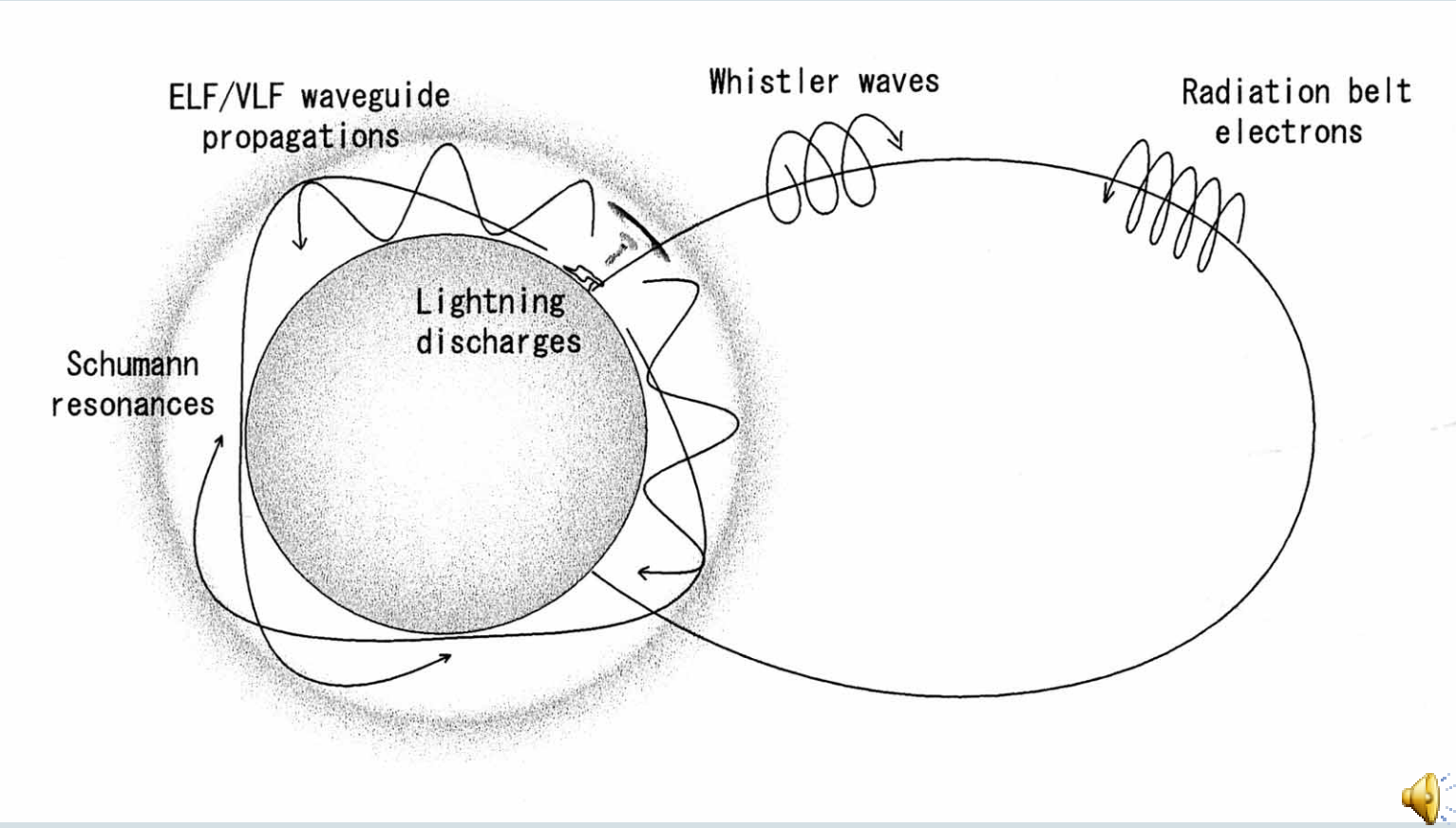
Telescopic Imaging of Sprites

- Wide (left panel) and narrow (right panel) field of view images of a bright sprite event [*Gerken et al.*, GRL, 27, 2637, 2000]:



- The measured streamer diameters are 61-145, 150, 196 m, for altitude ranges 60-64, 76-80, 81-85 km, respectively [*Gerken et al.*, 2000].

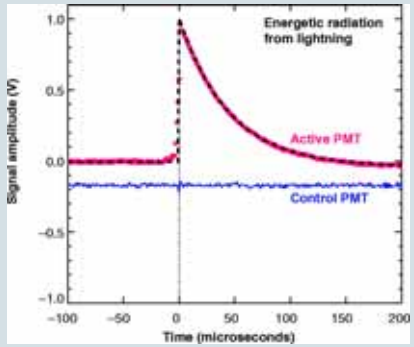
Whistlers



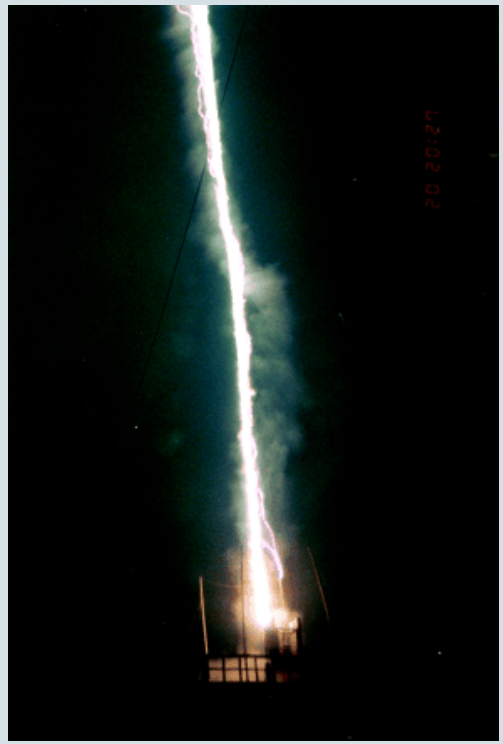
Samenhang met Schumann-resonanties

Energetic Radiation produced during rocket-triggered lightning
J.R. Dwyer et al.
Science 31 (2003) p 694-7

".. extremely penetrating corpuscular radiation.."



Using a NaI(Tl) scintillation detector designed to operate in electrically noisy environments, we observed intense bursts of energetic radiation (10 kiloelectron volts) during the dart leader phase of rocket-triggered lightning, just before and possibly at the very start of 31 out of the 37 return strokes measured. The bursts had typical durations of less than 100 microseconds and deposited many tens of megaelectron volts into the detector. These results provide strong evidence that the production of runaway electrons is an important process during lightning.



Capaciteit Ionosfeer - Grond

Waarde $4\pi\varepsilon_0 r^2/h = 46$ mF

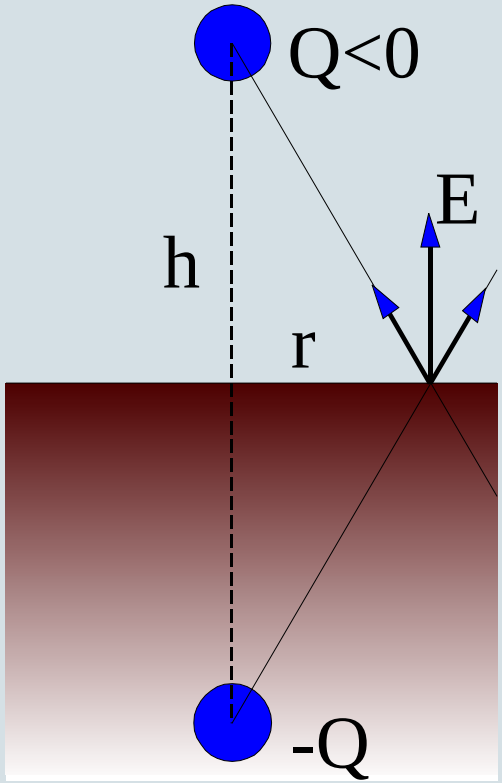
Spanning ± 250 kV

Mooi-weer veld 100- 200 V/m op grondniveau

Opgeladen door bliksem

50 fl./sec wereldwijd

Op de grond:



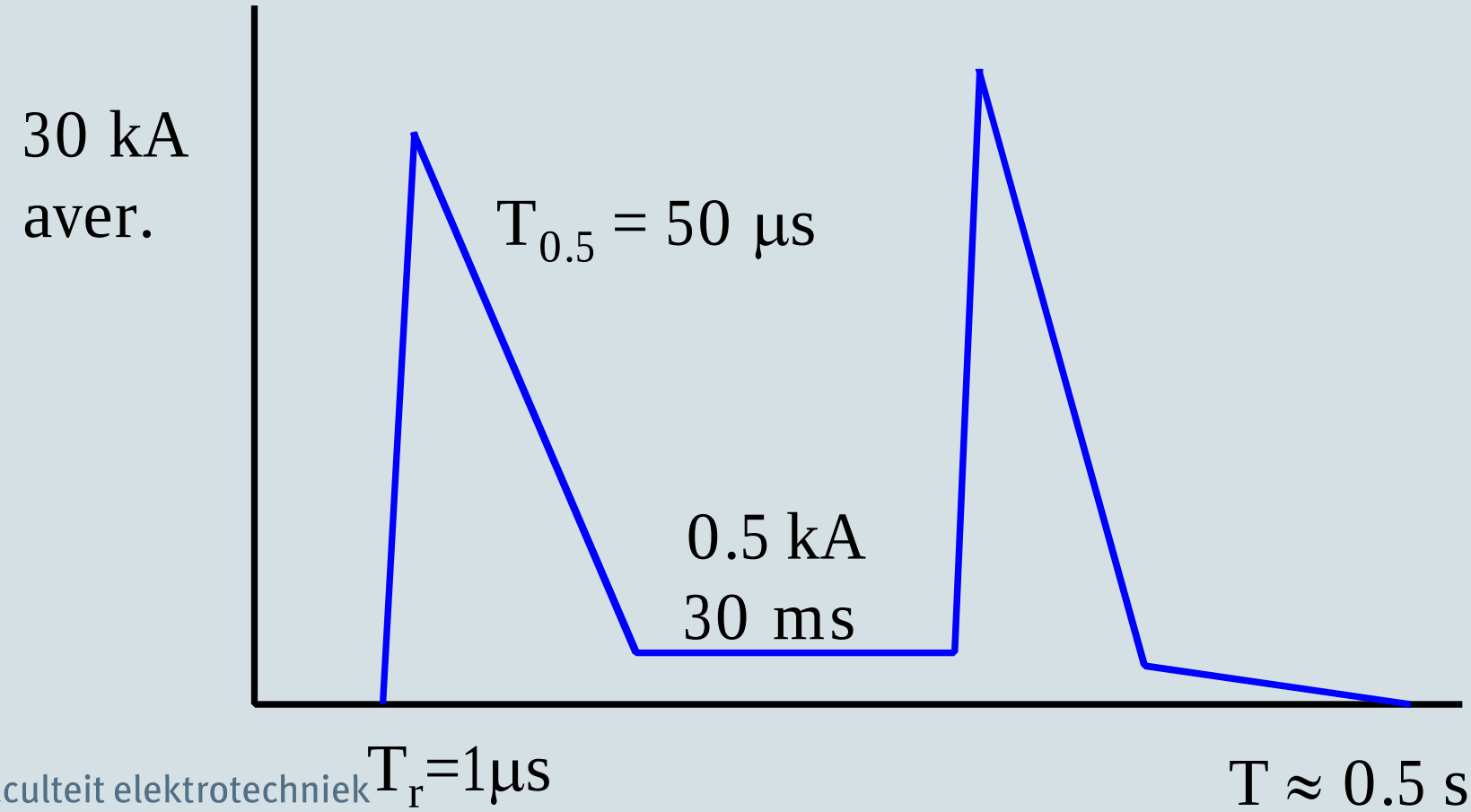
Q = -7 C
h = 2 km

$$E = \frac{2Q}{4\pi\varepsilon_0 R^2}\frac{h}{R}$$

$$R^2 = r^2 + h^2$$

No leader & r = 0:
32 kV/m

Lightning current waveform



Lightning current waveform

Fast & slow components

- Q: 10 - 900 C
- I_p: 20 - 200 kA
- dI/dt:10^{11} A/s

- Slow comp.: Fire, life, mechanical damage
- Fast components: Threat for electronics

Lightning as source of disturbances

- Capricious, often standardized to 1/50 μs
- large dI/dt: 10^{11} A/s

Protection

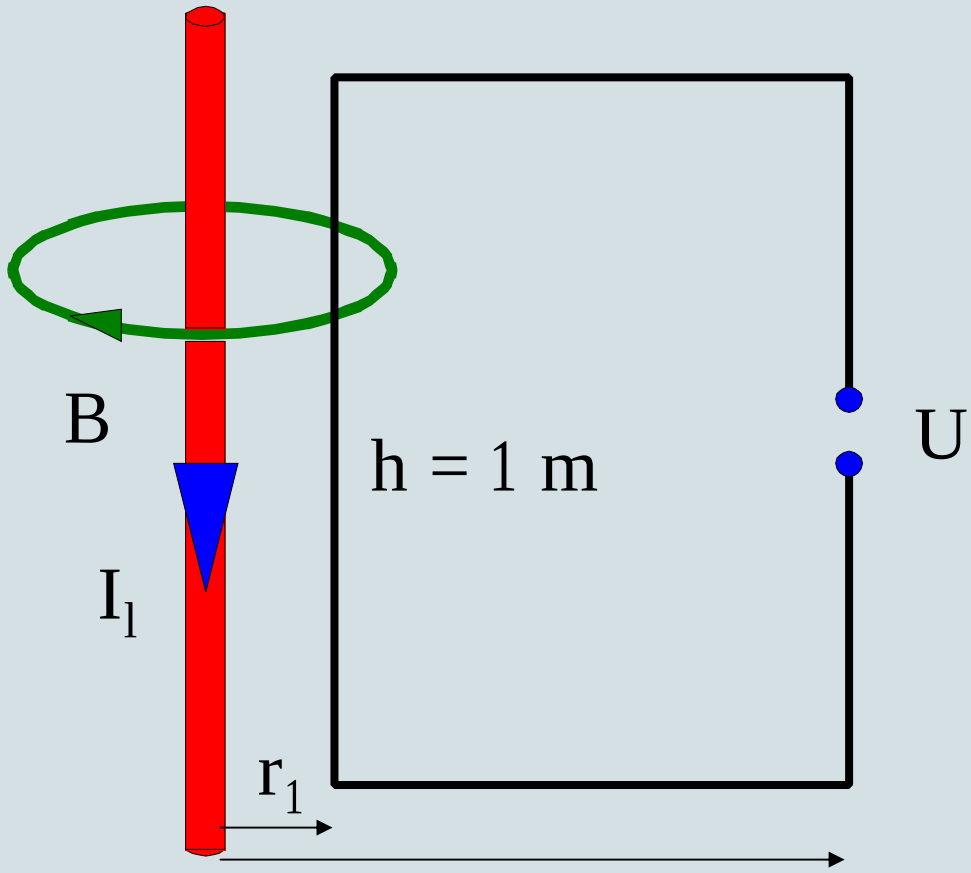
- Fire: slow tail, $\int i^2 dt$
- Life: also tail
- Both cases: mm^2 of copper counts

M-coupling

$$M = \frac{\mu_0}{2\pi} h \ln \frac{r_2}{r_1}$$

$$U = M \, \partial I / \partial t$$

r_1	U
2 m	8 kV
1 km	20 V



$$\partial I / \partial t = 10^{11} \, A/s$$

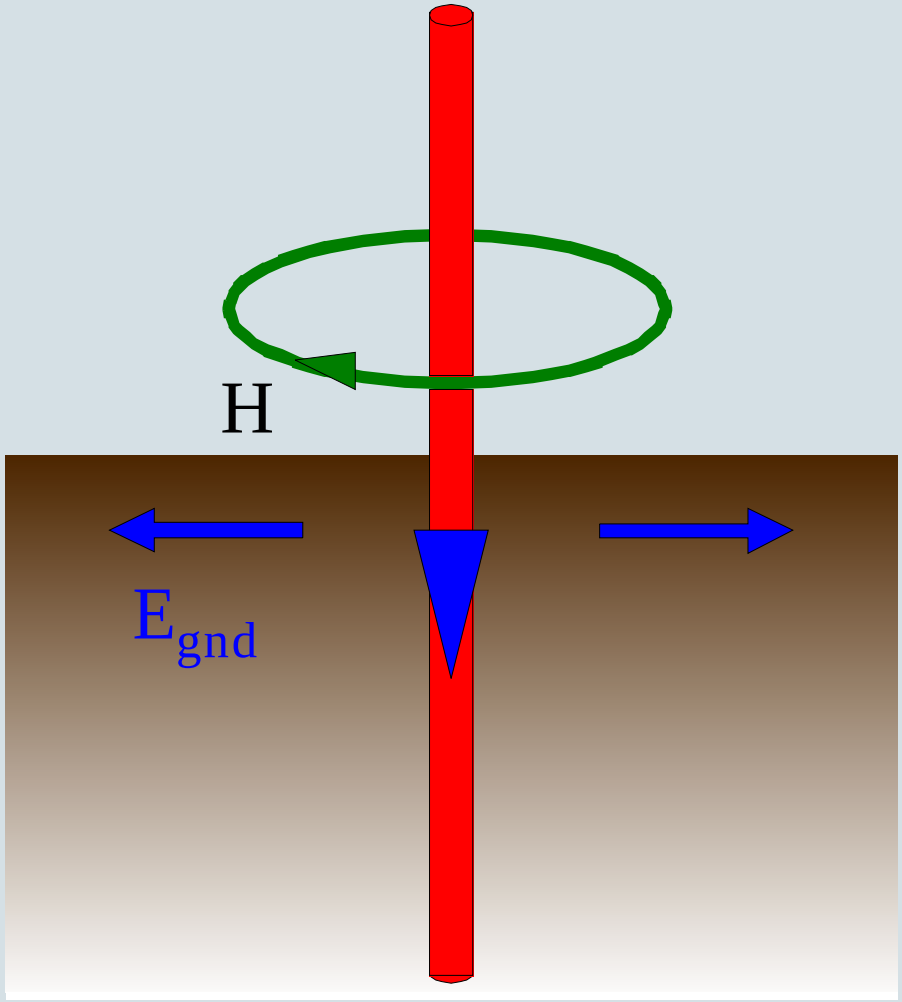
Soil effects

$$H = \frac{I}{2\pi r}$$

$$E_{gnd} = Z_{surf} H$$

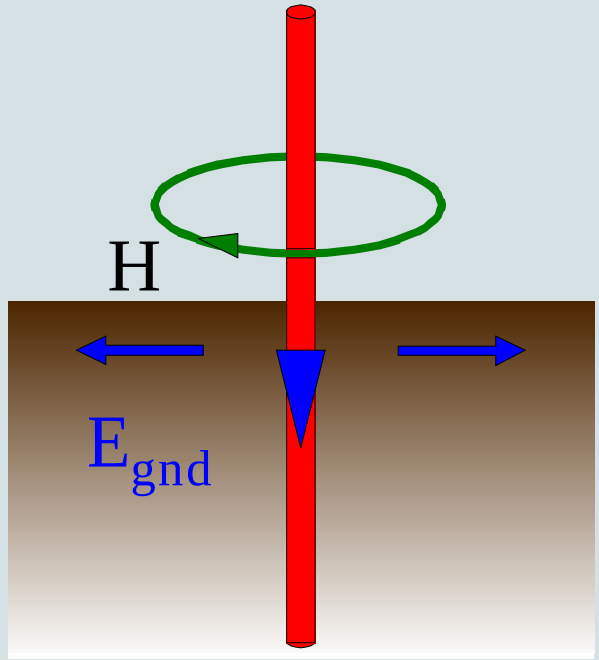
$$| Z_{surf} | = \rho / \delta$$

$$\delta = \sqrt{2\rho\tau / \mu_0}$$



Soil effects

τ	δ	Z_{gnd}	E (r = 1m)
1 μs	13 m	8 Ω	130 kV/m
70 μs	105 m	1 Ω	15 kV/m



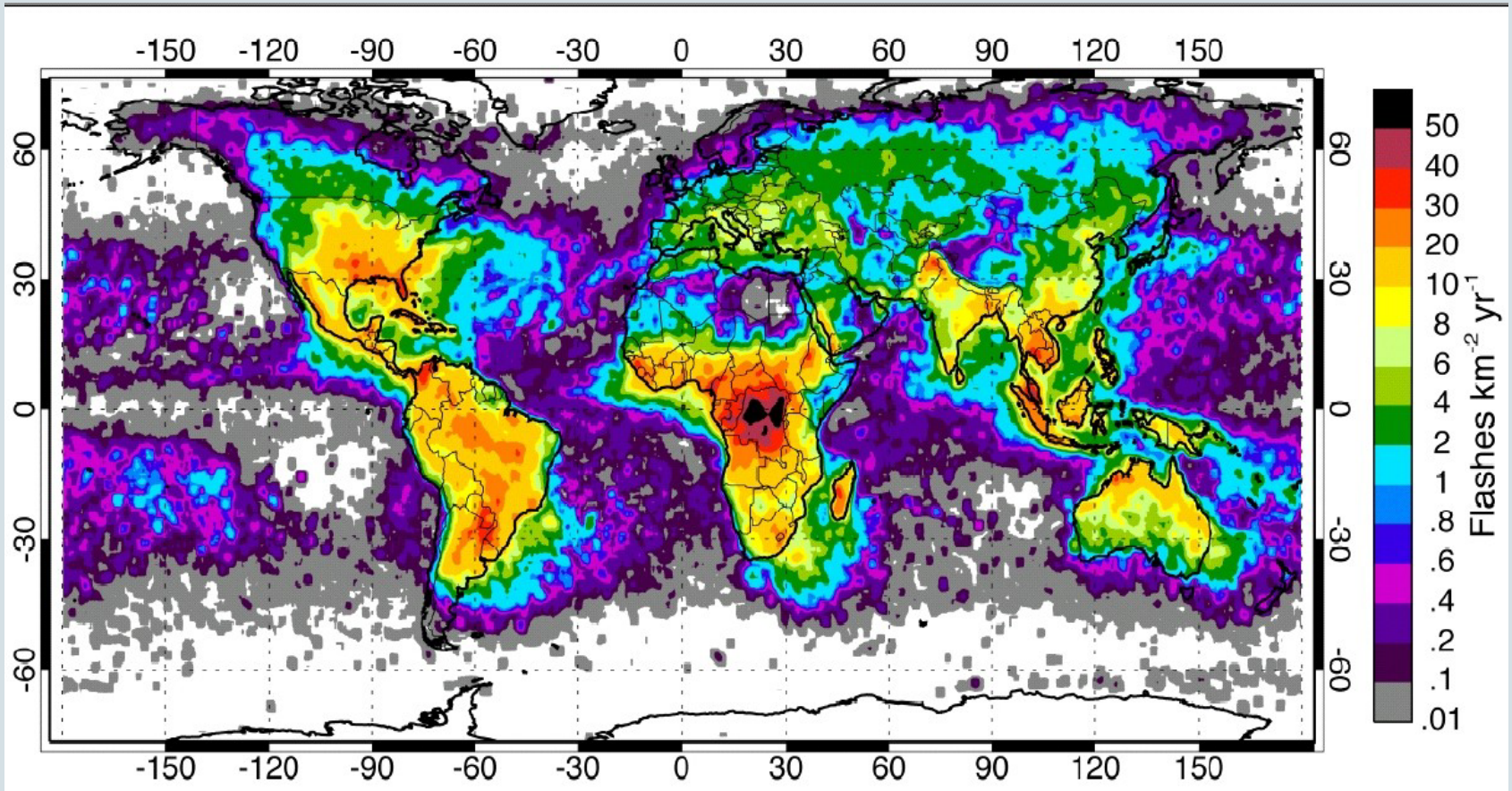
Cables 0.5m deep in soil:
front and tail

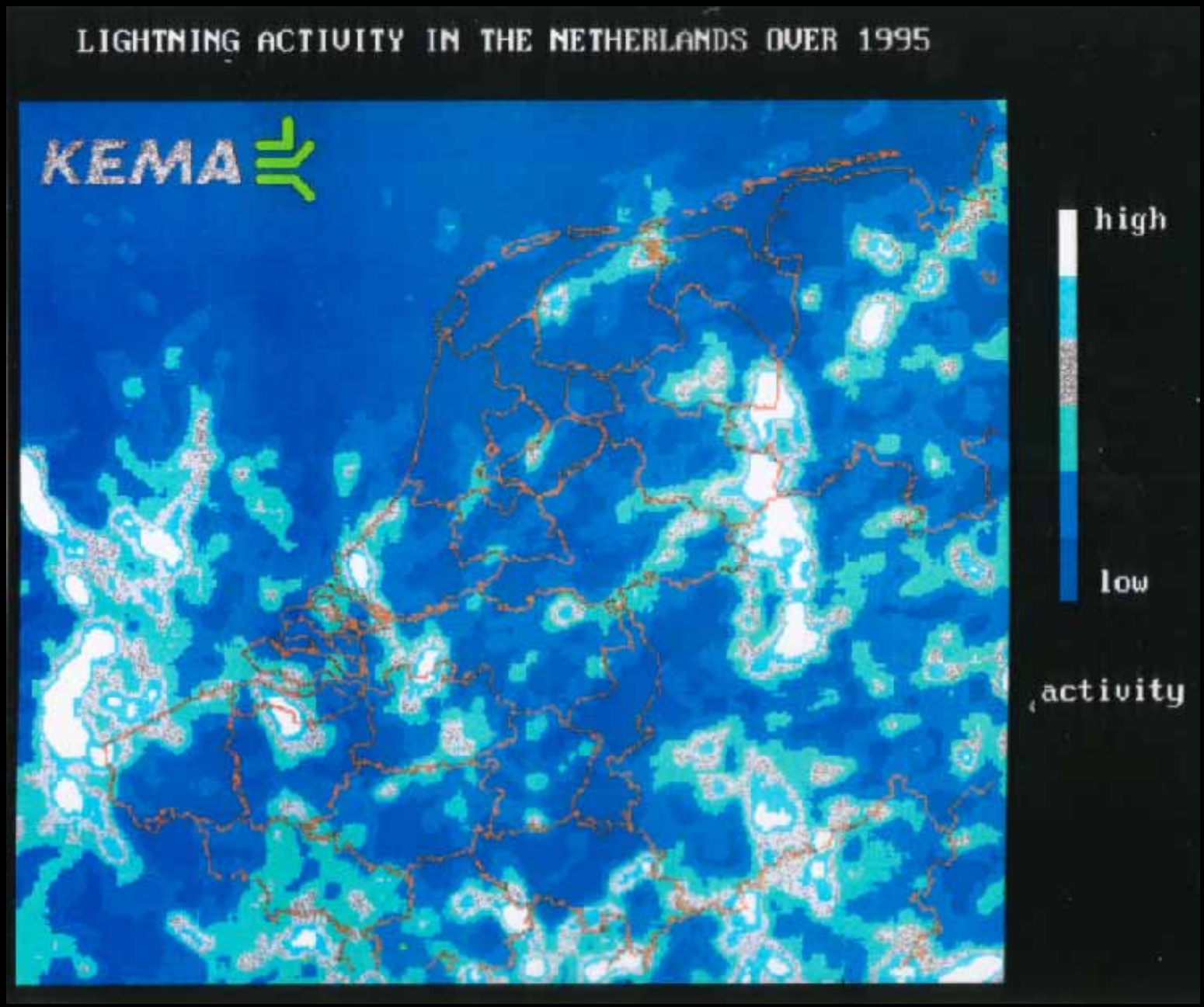
$I = 10^5$ A
50 mm^2 Cu
length = 15 m
$\rho = 10^2$ Ωm
R_{dc} = 10 Ω

Threats for electronics:

- Partially grown discharges
- Antennas for strong fields
- Secundary discharges and sparking over

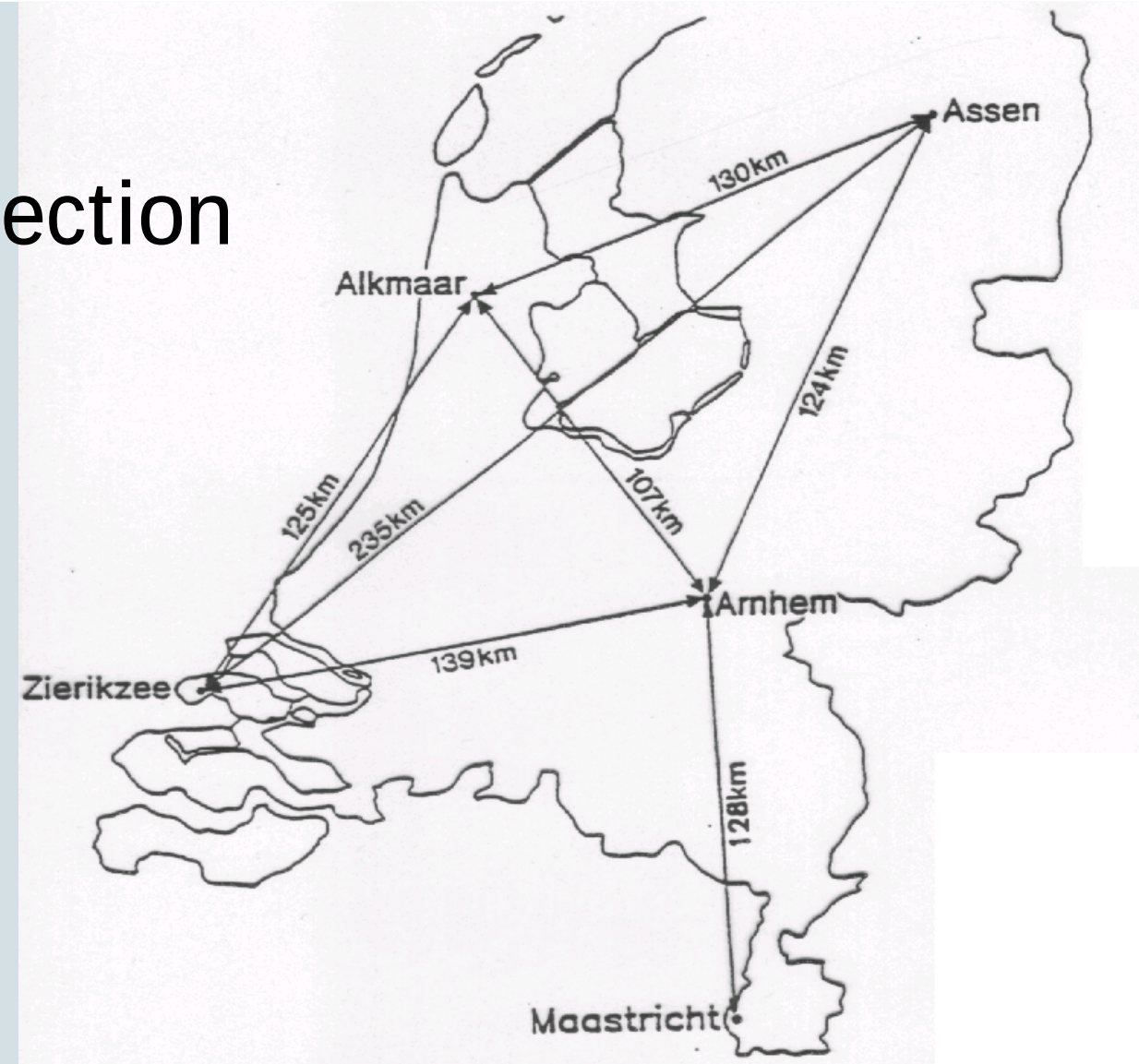
Global Lightning

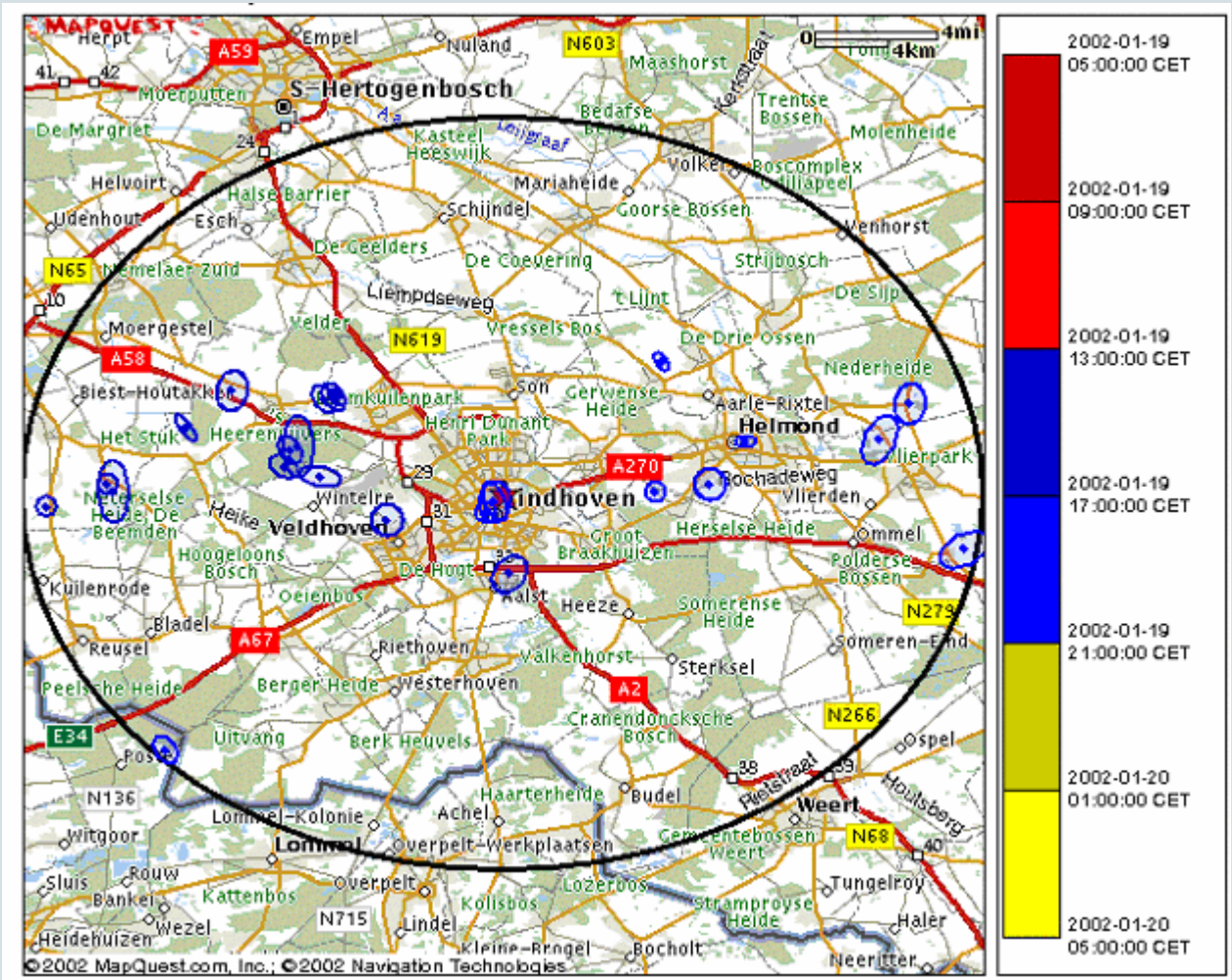



LIGHTNING ACTIVITY IN THE NETHERLANDS OVER 1995
KEMA
high
low
activity

Kema lightning detection

Average per yr:
2-4 strokes/km^2





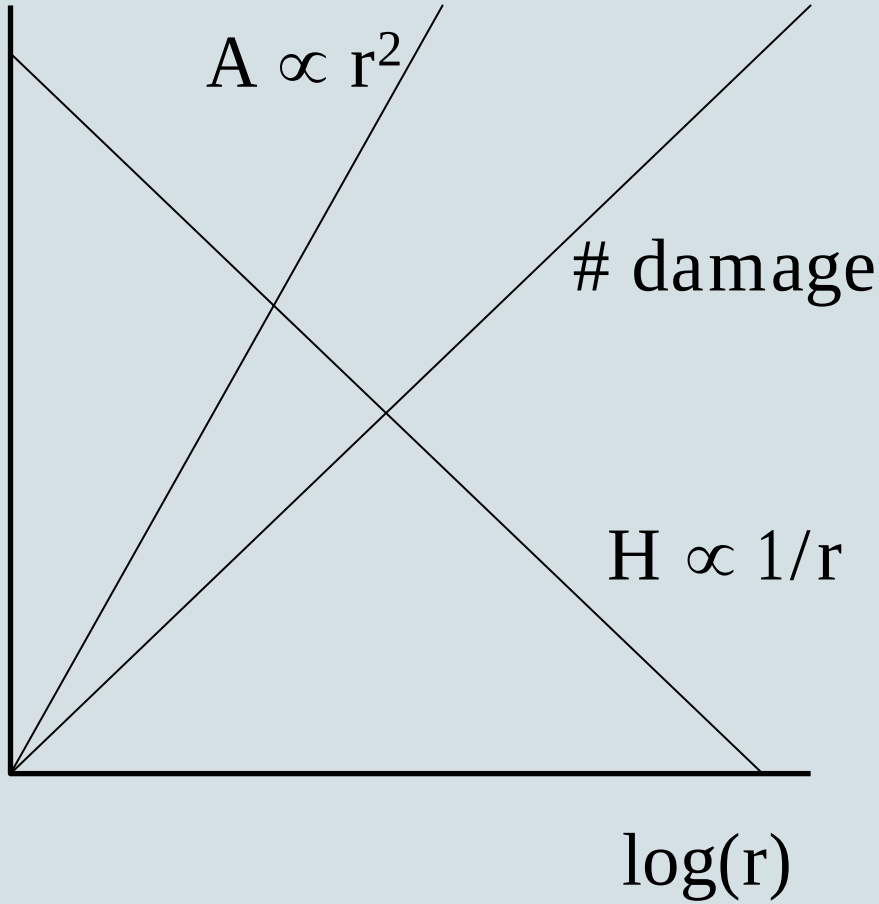
19 jan 2002, 17.03 uur: 16 kA

Increasing importance of LP

- Increasing number of critical installations
- Stronger dependence of correct functioning
- Higher reliability requested
- More interconnections

Density of electronics

- Fixed # lightning flashes per km^2
- Area prop. to r^2
- # electronic apparatus increases

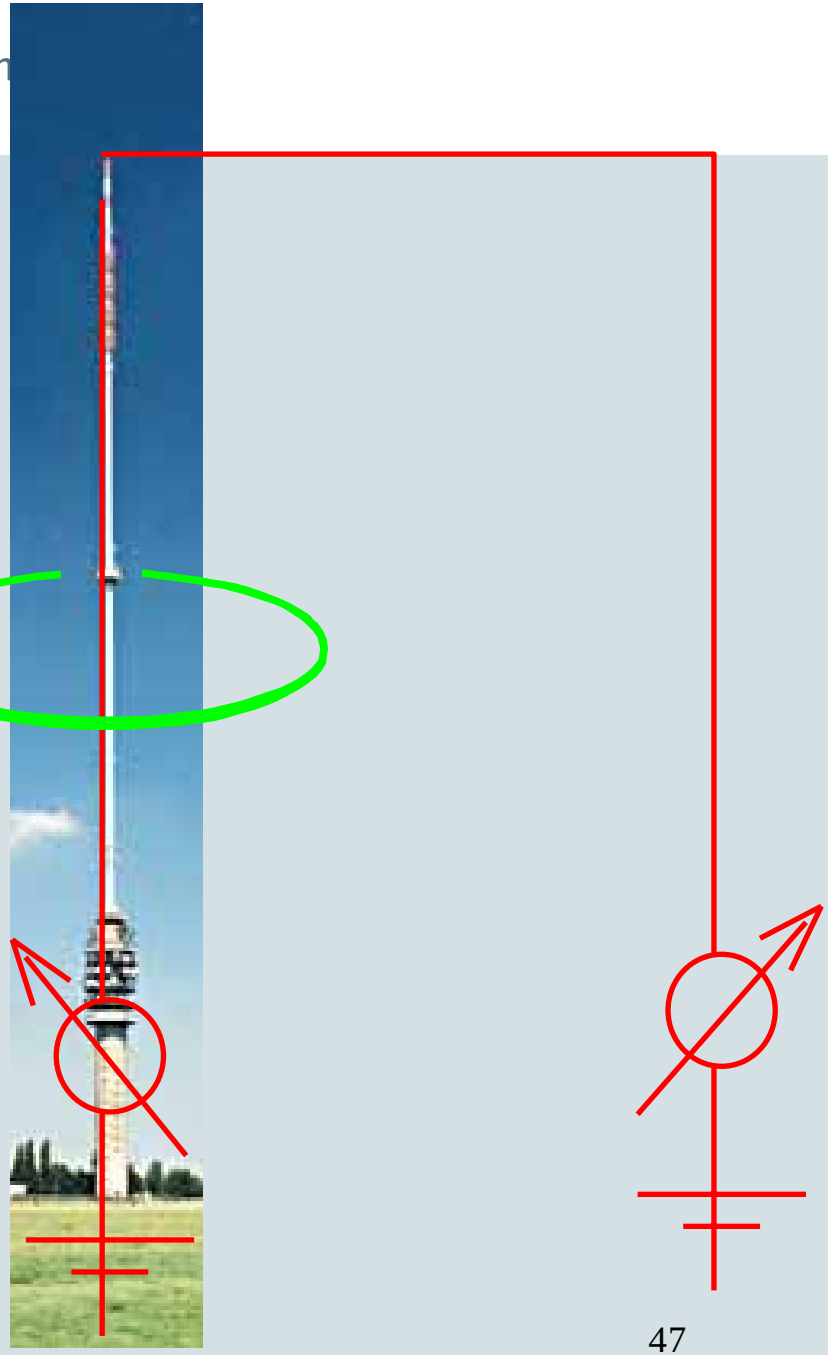


Positive protection method

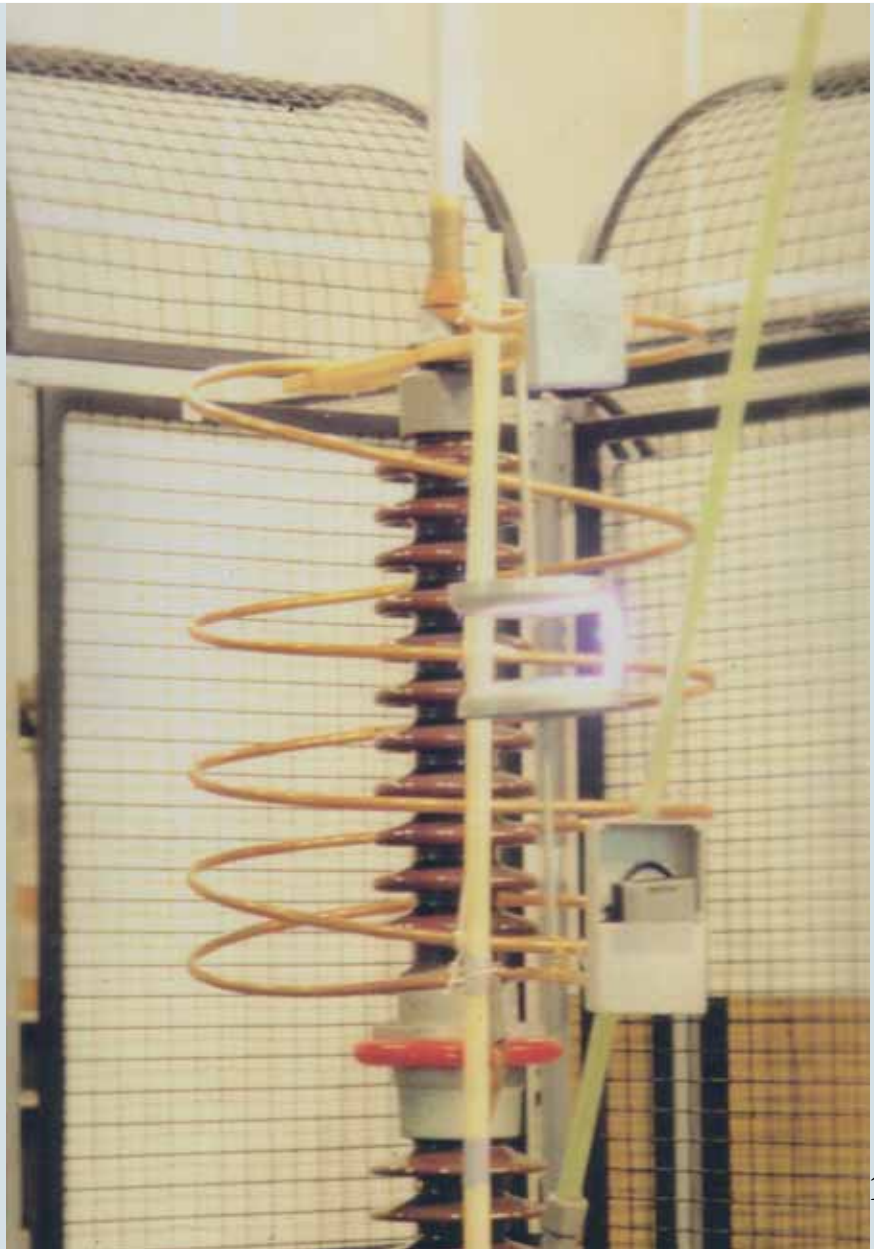
- Offer path for lightning current
- Ensure low Z_t w.r.t.
  - human beings (safety)
  - electronics
- Large scale: buildings, cabling
- Small scale: near electronics

Voltage on top?

- Voltages due to induction
- Current indeed
- Voltage depends on path
- Near zero possible inside tube



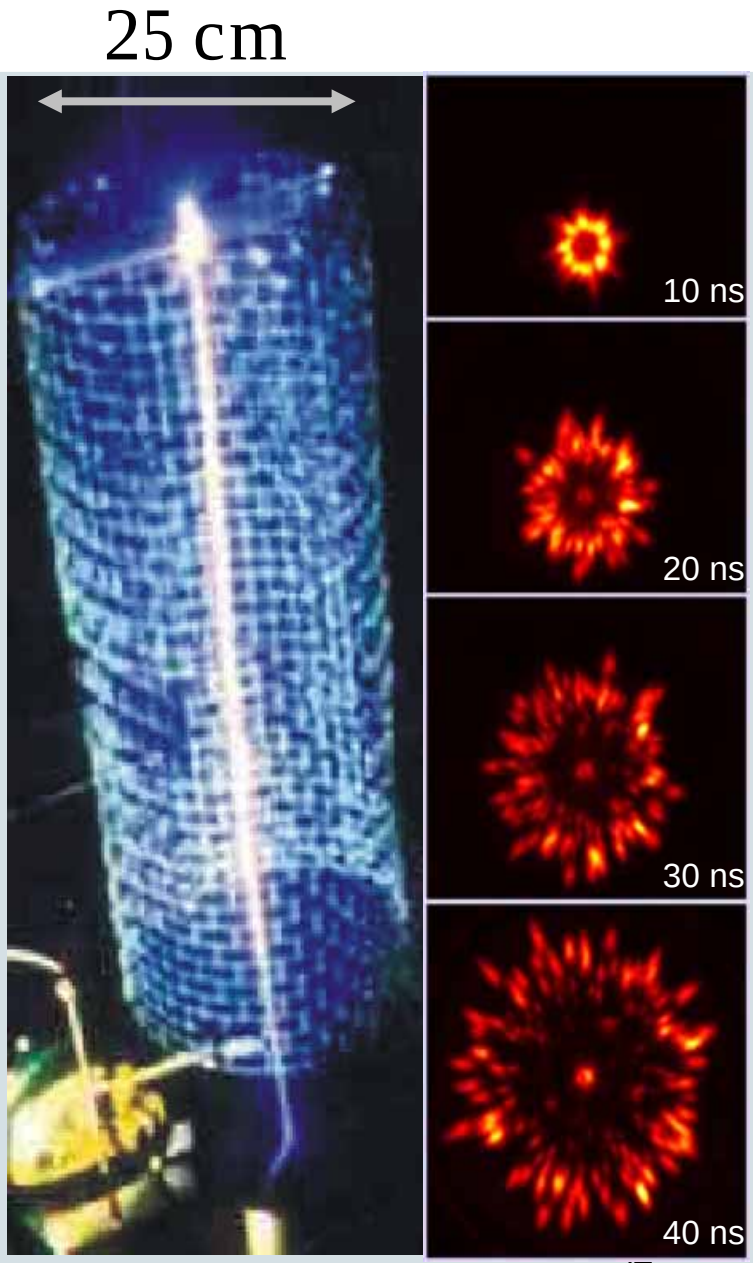
Walkman demo



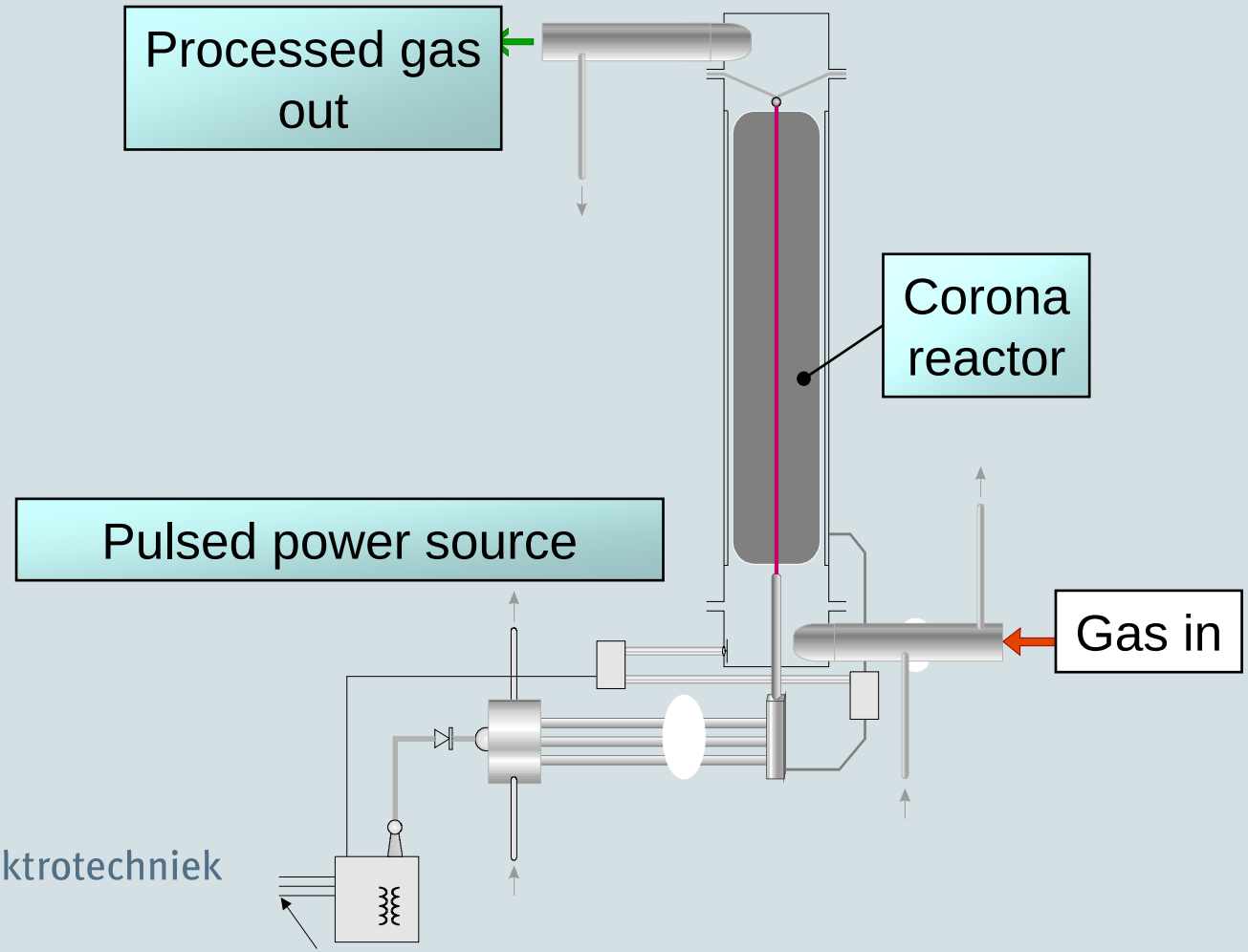
survelec 4:30 – 6:09

Van km naar dm schaal

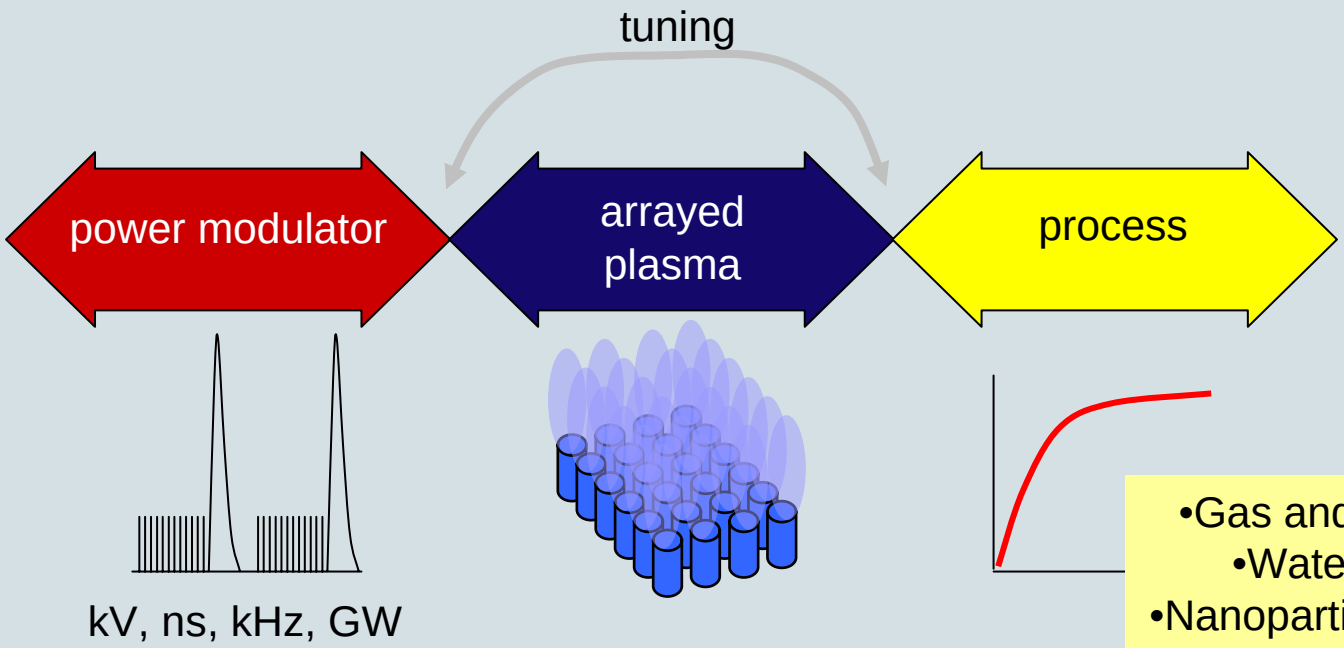
- Corona ontladingen in lab / industrie
- Gepulst:
  - meer C/s
  - hogere spanningen
  - meer energie



Electrostatic Pollution Control



Pulsed power processing



- Gas and air cleaning
- Water cleaning
- Nanoparticle production
- X-UV
- Bacteria, μ-organisms
- Shock waves
- Rock drilling

30 kW Hybrid pulsed corona reactor

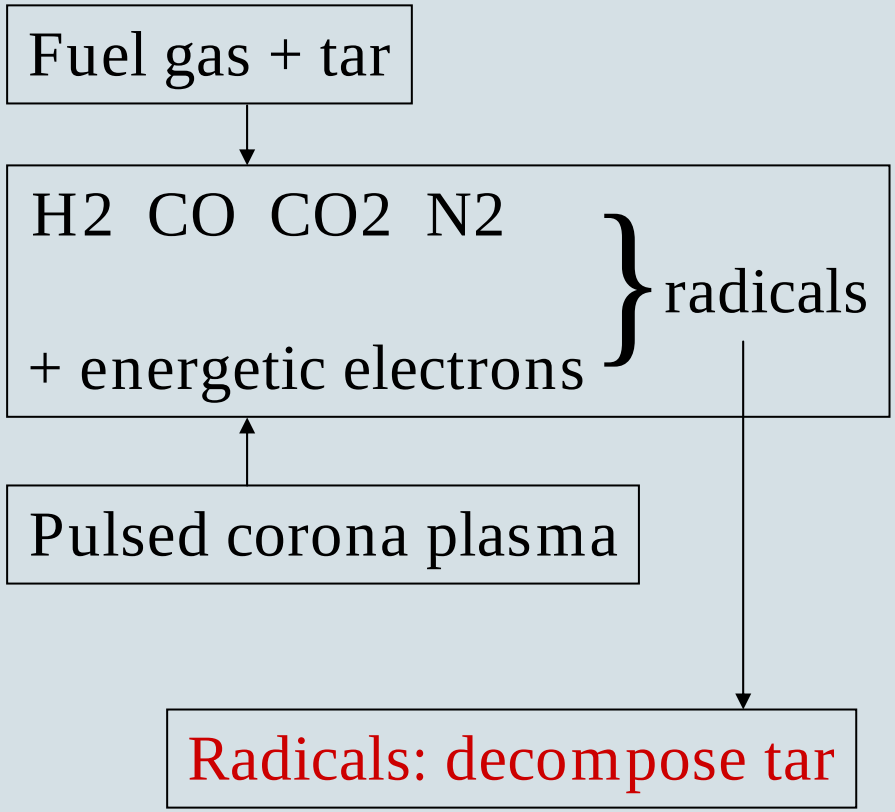
Now:

- 100 kV, 5 ns rise, 100 ns wide
- 12 J/pulse, 1000 pps
- 10 kW_{avg}
- >80 % efficiency

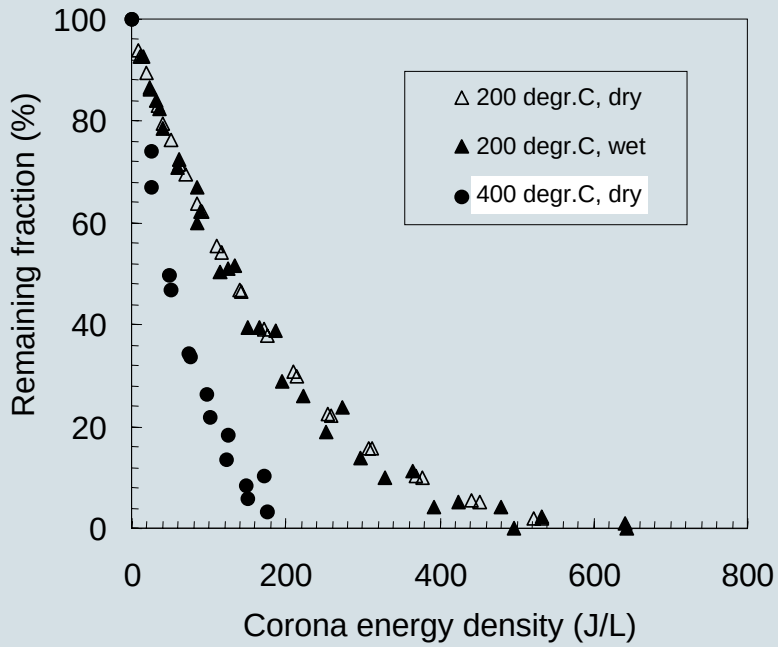
Next target:

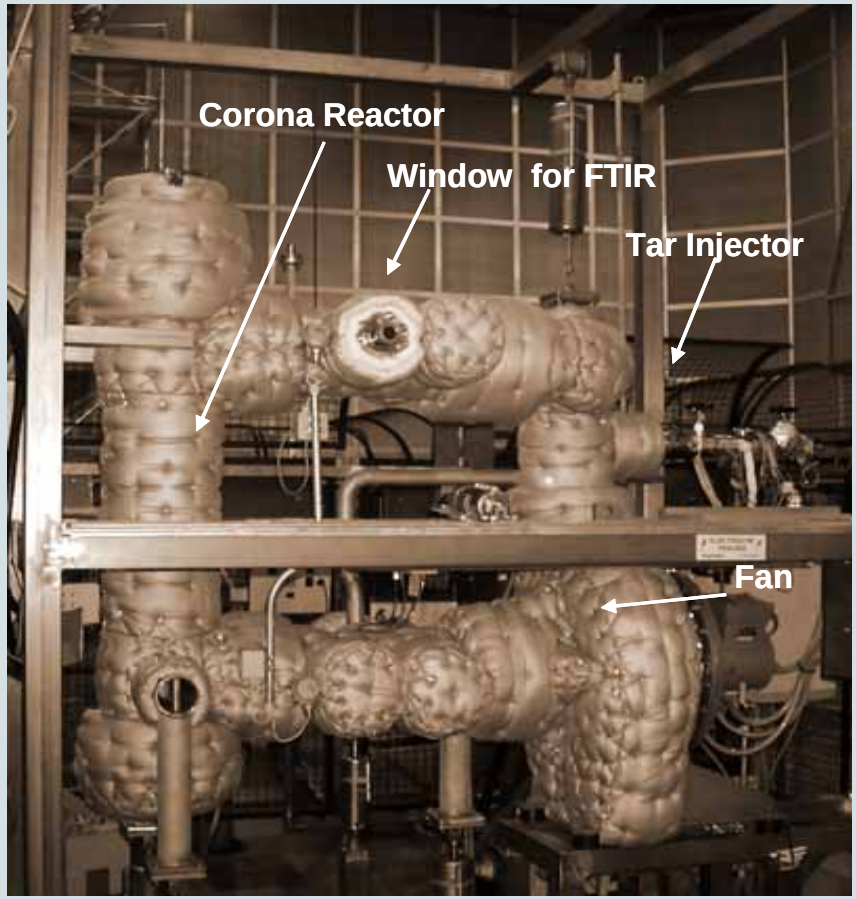
- 100 J/pulse, 1000 pps
- 100 kW_{avg}
- Multiple switches

Corona induced tar removal in fuel gas



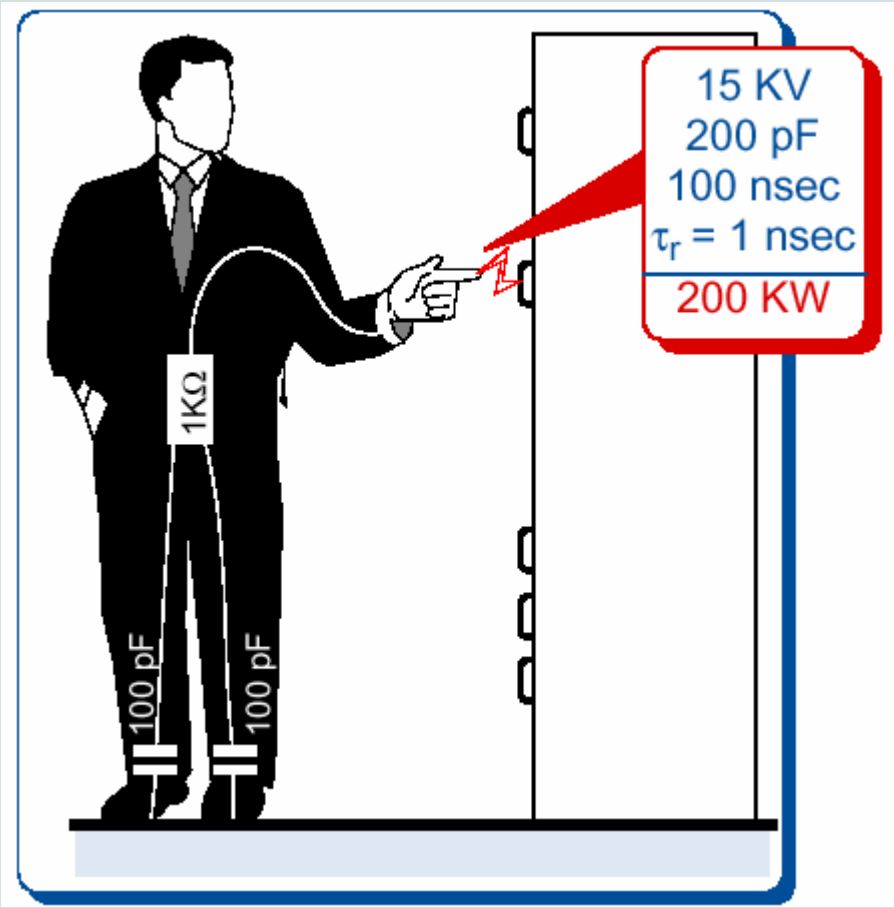
Effect of temperature on corona tar removal in synthetic fuel gas

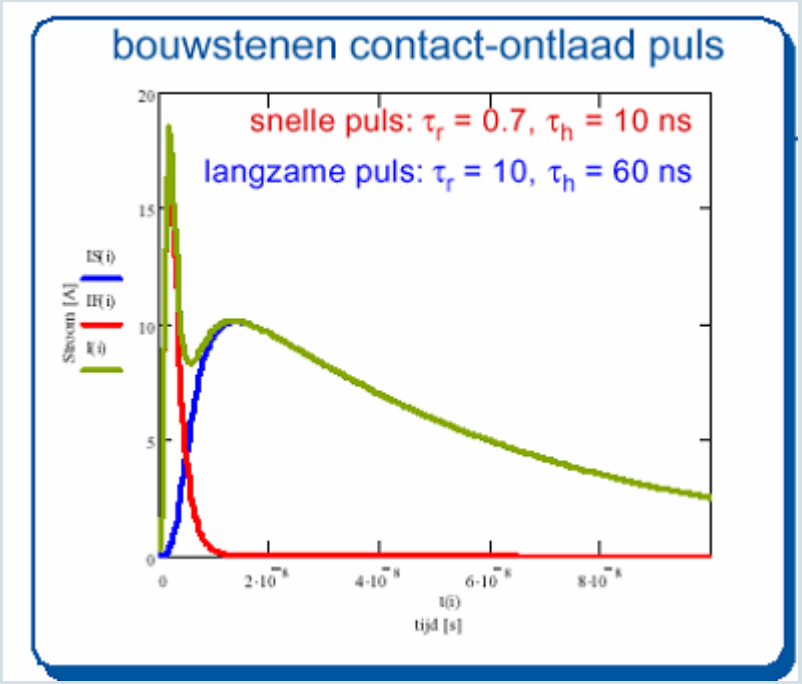




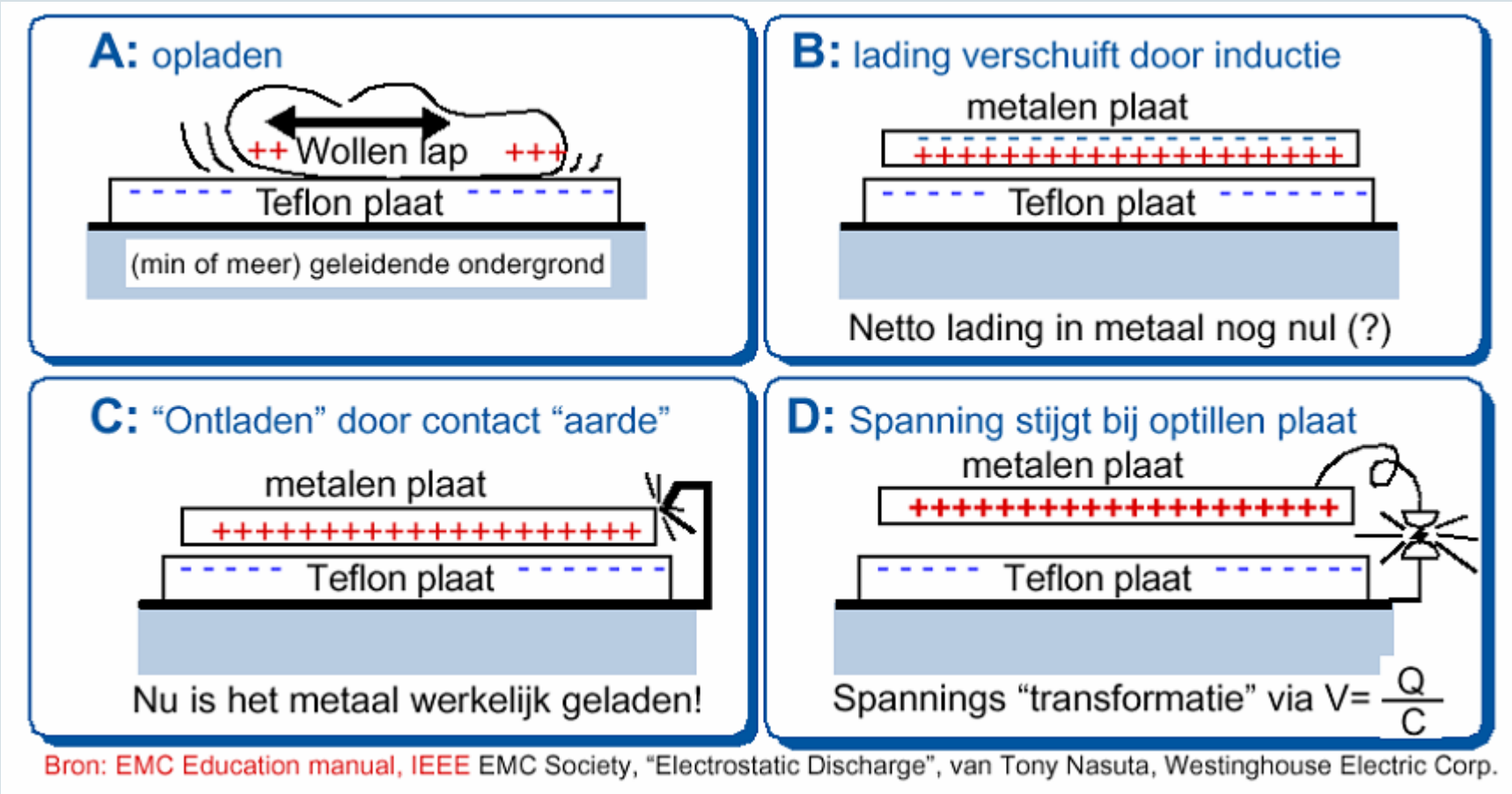
Van dm naar mm schaal:

- Electrostatische ontlading
  - Hoge spanningen, 15 kV
  - Grote stroom, 10 A
  - Korte stijgtijden < 1 ns
- Schadelijk voor elektronica
  - storen
  - beschadigen





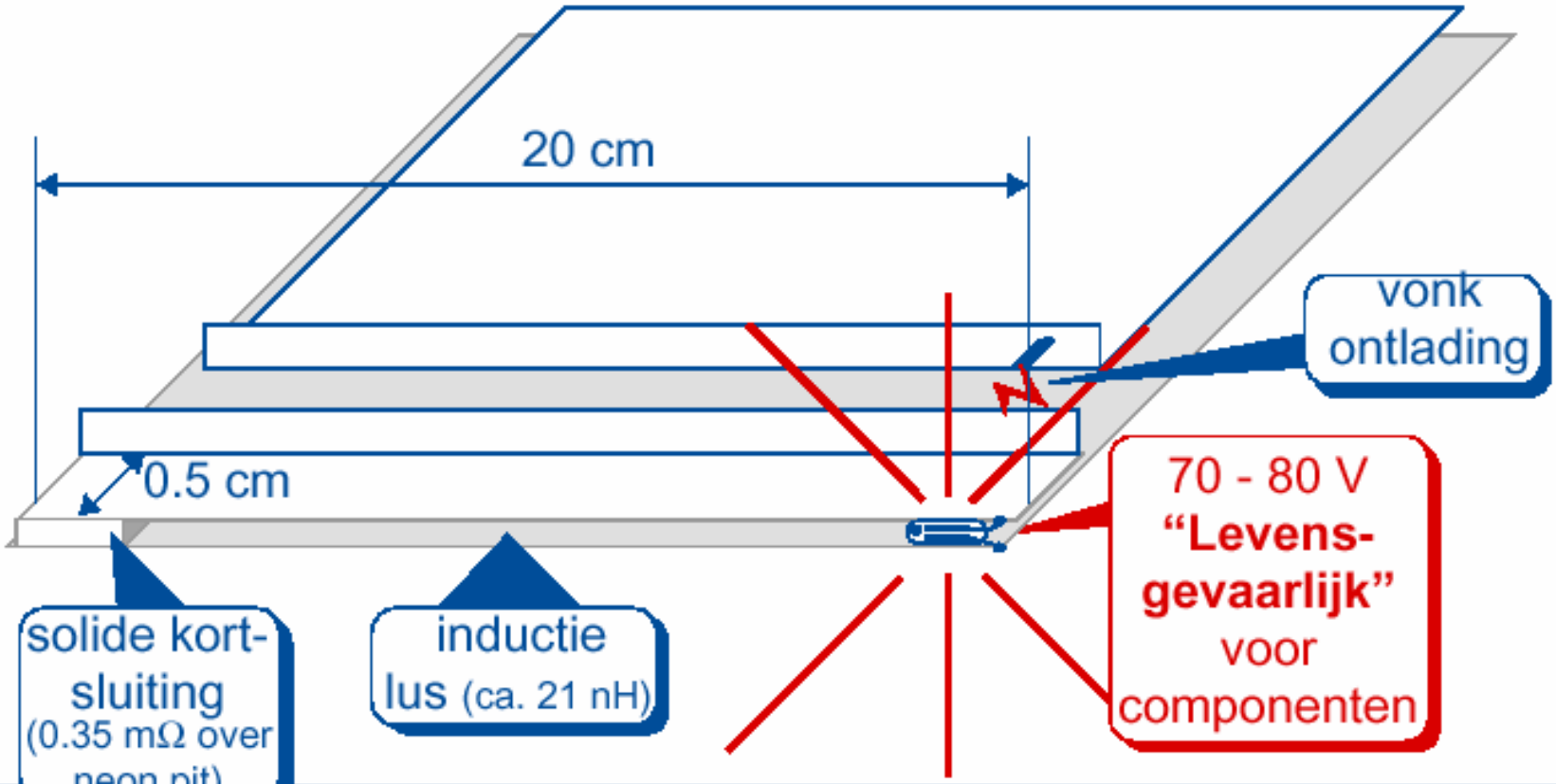
Demo
met dank aan
F. Buesink,
Thales



Bron: EMC Education manual, IEEE EMC Society, "Electrostatic Discharge", van Tony Nasuta, Westinghouse Electric Corp.

ESD inductie demonstrator

"ground-lift" spanning doet neon pit oplichten!



BBC NEWS

Man's static jacket sparks alert

- An Australian man built up so much static electricity in his clothes as he walked that he burned carpets, melted plastic and sparked a mass evacuation. Frank Clewer, of the western Victorian city of Warrnambool, was wearing a synthetic nylon jacket and a woollen shirt when he went for a job interview.
- As he walked into the building, the carpet ignited from the 40,000 volts of static electricity that had built up.
- "Within about five minutes, the carpet started to erupt,"
- Perplexed firemen evacuated the building and cut its electricity supply, thinking the burns could have been caused by a power surge.
- "There were several scorch marks in the carpet, and we could hear a cracking noise - a bit like a whip - both inside and outside the building,“
- Mr Clewer said that after leaving the building, he scorched a piece of plastic in his car. His clothes were measured by firemen as carrying an electrical charge of 40,000 volts ....

Warrnambool Standard, 16 september 2005: Man's static jacket sparks alert

- The story has been picked up by The Register, Guardian, BBC, USA Today, Reuters, local agencies of ABC, the San Francisco Chronicle, and other news outlets.
- Several unanswered objections mark the story as a possible hoax. See: http://en.wikinews.org/wiki/Australian_man_allegedly_ignites_carpet,_plastic_with_static_electricity

Links:

http://www.lc.leidenuniv.nl/lc/web/2005/20050509/info.php3?wsid=155

http://www.emc-esd.nl

www.lightningsafetyalliance.com/

http://www.nssl.noaa.gov/researchitems/

http://emcwww.epfl.ch/iplt/index.htm

Links:

- http://www.gi.alaska.edu/ScienceForum/ASF12/1209.html
- elf.gi.alaska.edu/sprites.html
- www-star.stanford.edu/~vlf/optical/press/elves97sciam/
- http://www.eurosprite.net/

- Google: trefwoorden "sprites" en "alaska"