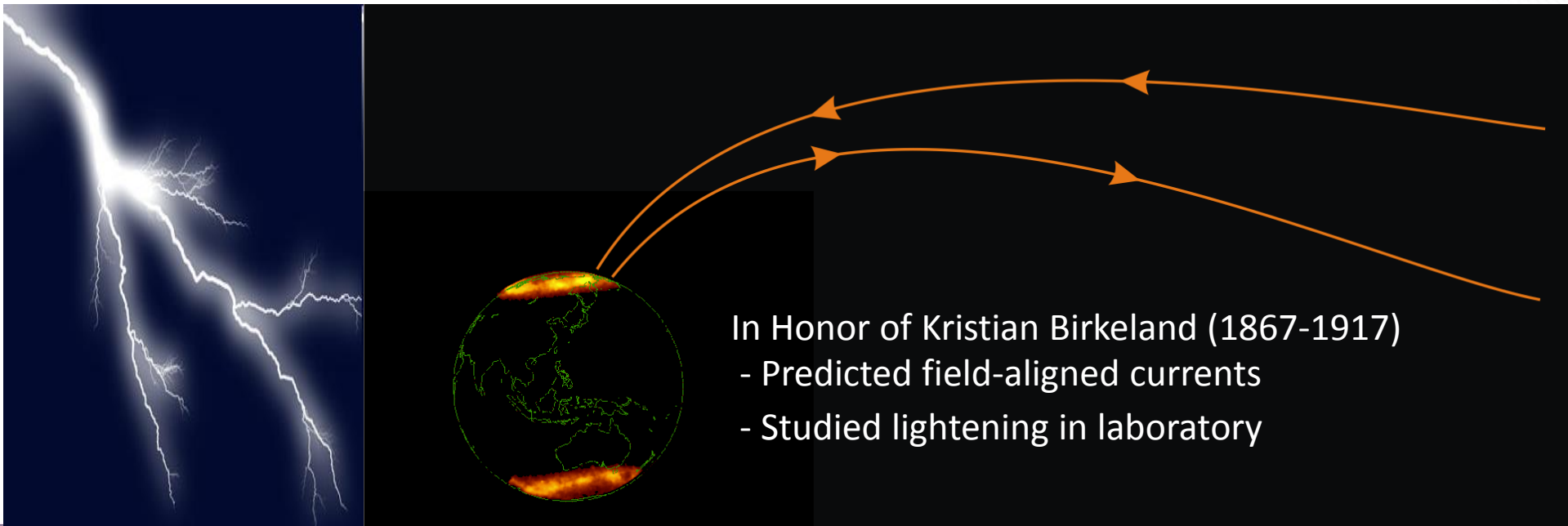


Birkeland Centre for Space Science

How Earth is coupled to space



How is Earth coupled to space?

- 4 main questions – 4 science groups
- 2 instrumentation groups
- Education and Public outreach group
- UiB – UNIS – NTNU
- ~50 people + 20 Master students

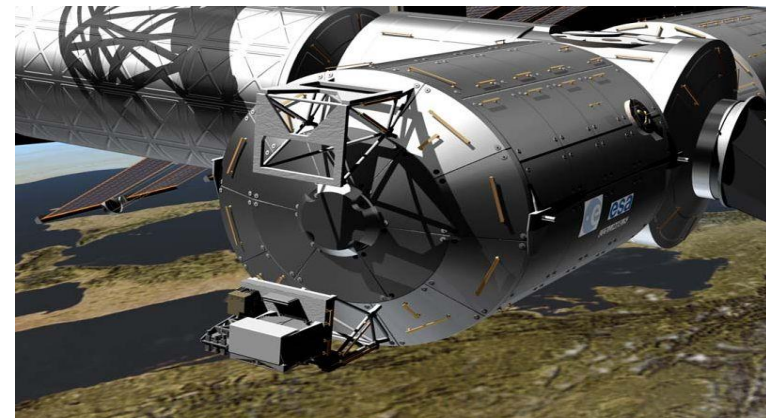
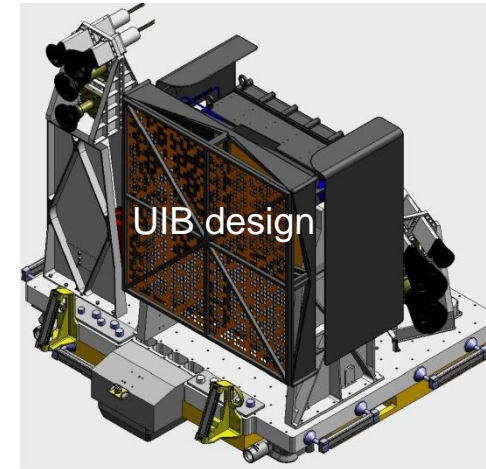


Q1: When and why is the aurora in the two hemispheres asymmetric?

Q2: How do we get beyond the large-scale static picture of the ionosphere?

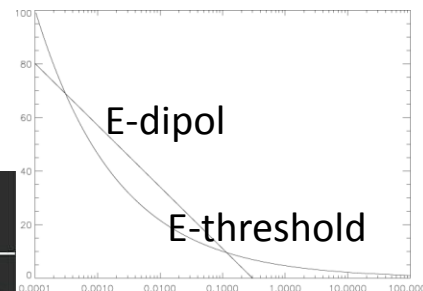
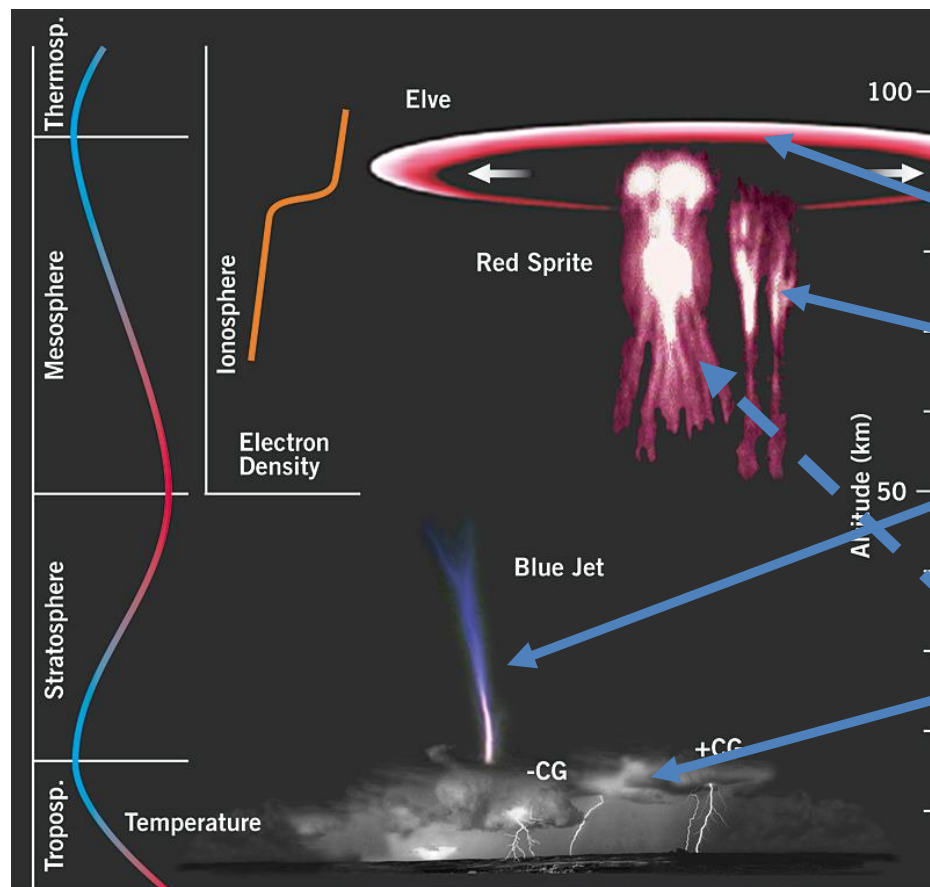
Q3: What are the effects of particle precipitation on the atmospheric system?

What is the role of
relativistic
electrons and antimatter
from thunderstorms
in geospace?



ASIM on ISS

Predictions!

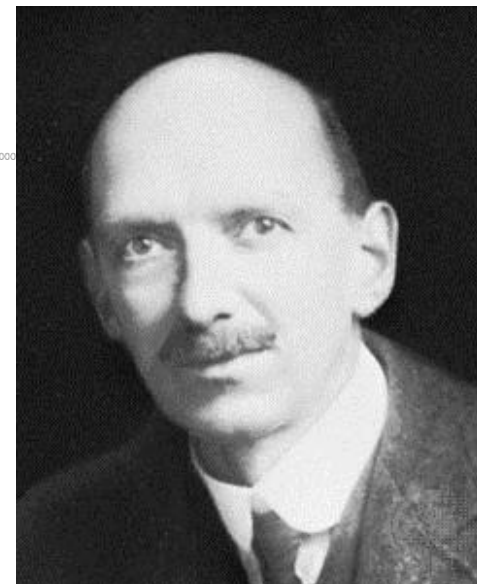


Elves

Red Sprites

Blue jets

Terrestrial
Gamma-ray
Flashes



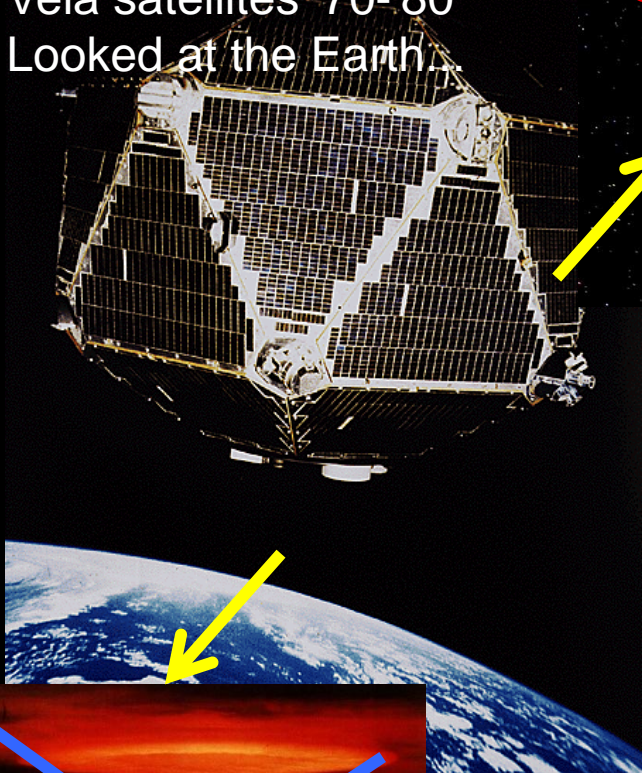
C. T. R. Wilson
Nobel prize physics 1927

“The electric field of a thundercloud and some of its effects” 1925:

Something has to happen above thunderstorms!

Discovered by a case of Serendipity

Vela satellites '70-'80
Looked at the Earth



Galactic gamma

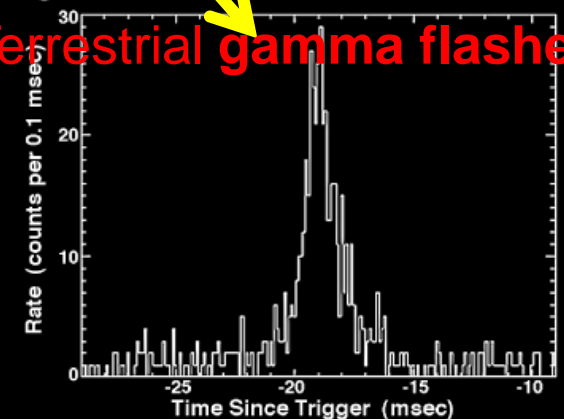


BATSE on CGRO 1991 – 2000
Looked to space...



Light Curve for a Terrestrial Gamma Flash

Terrestrial gamma flashes

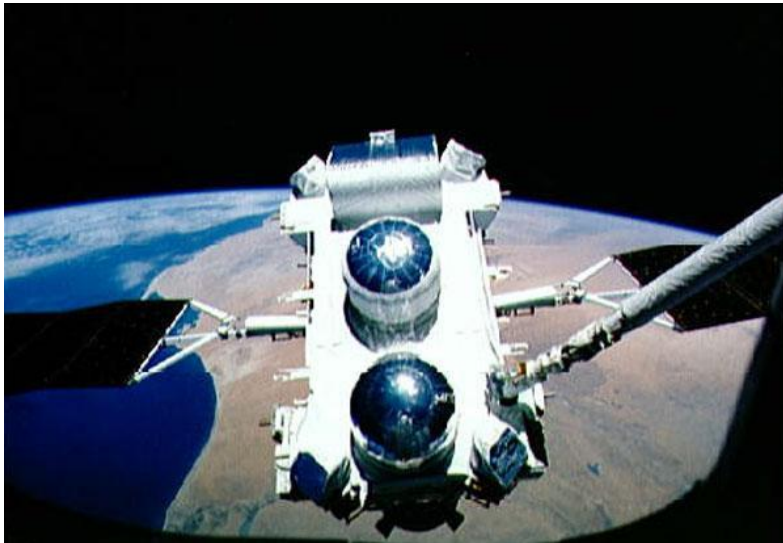




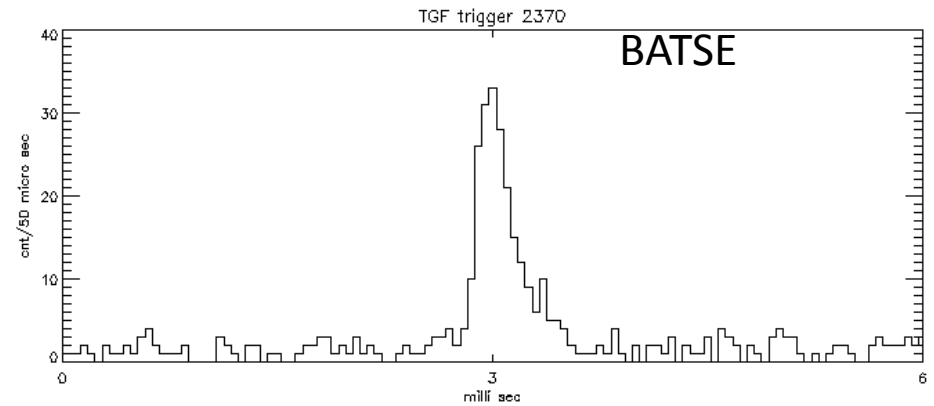
Relativistic
particles through
the atmosphere and
into space

An unknown
source of particles
from Earth to space

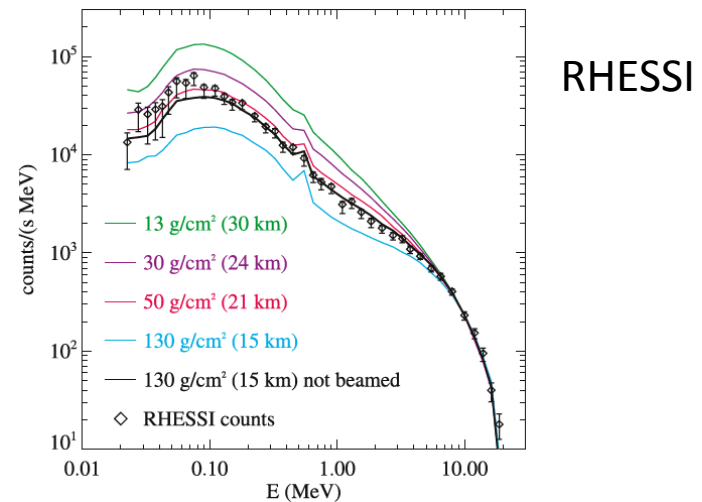
Terrestrial gamma-ray flashes - discovered in 1991



BATSE
Compton Gamma Ray Observatory



- Typical: < 1 ms
- Energies > 40 MeV
- produced < 20 km



How common are TGFs?

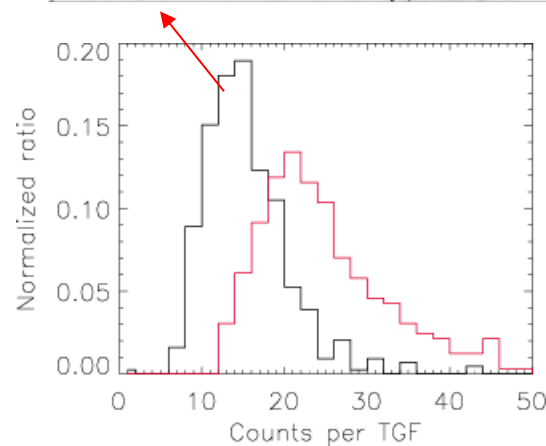
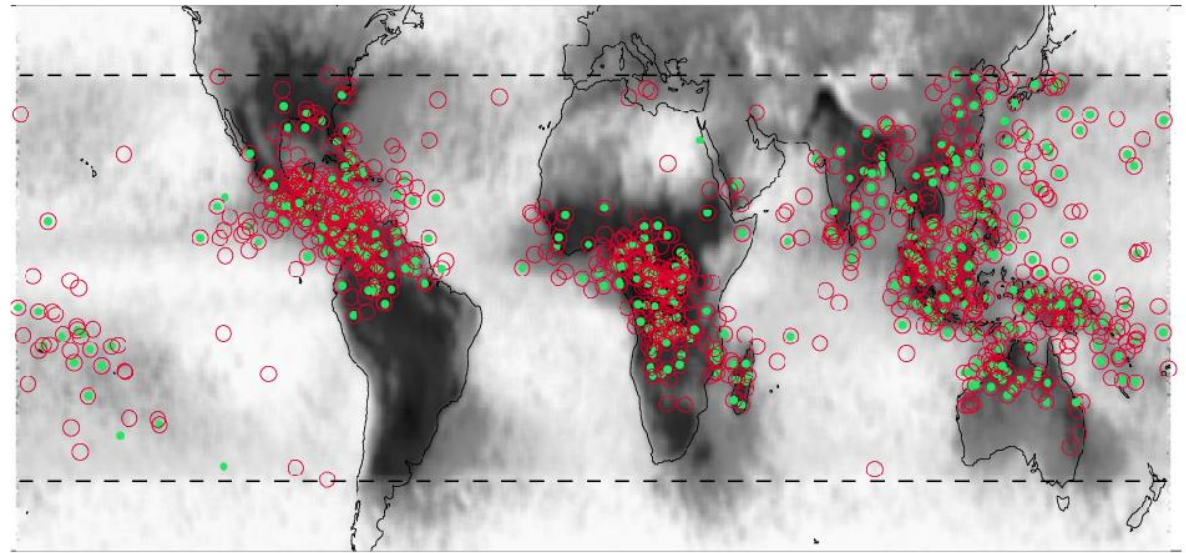


BATSE: 78 TGF - 9 year



RHESSI: 820 TGF - 6 year

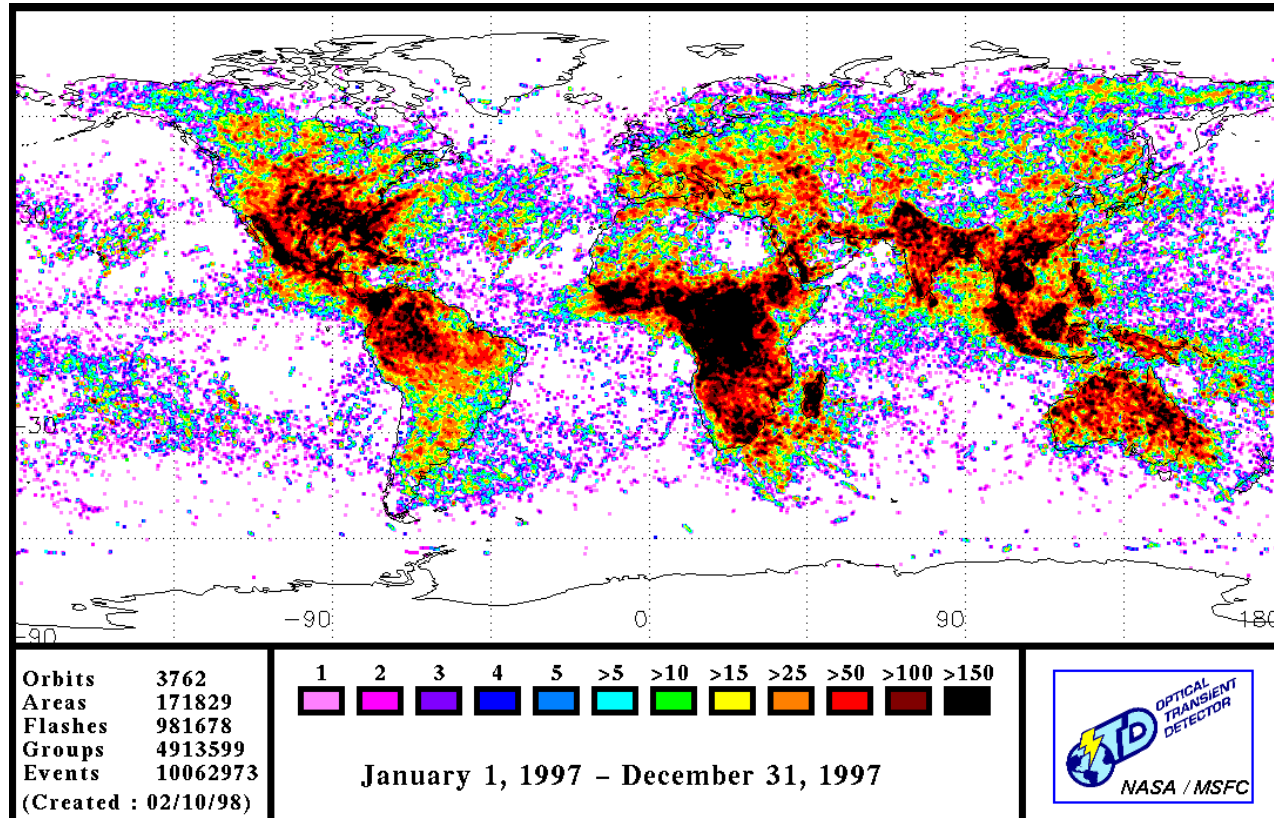
New analysis of RHESSI gave twice as many
200-300 observed pr year – global production rate of
50 000 per day (*Gjesteland et al, 2012*)



Tip of an iceberg?

Do all lightning produce TGFs
A million per day?
(*Østgaard et al., 2012*)

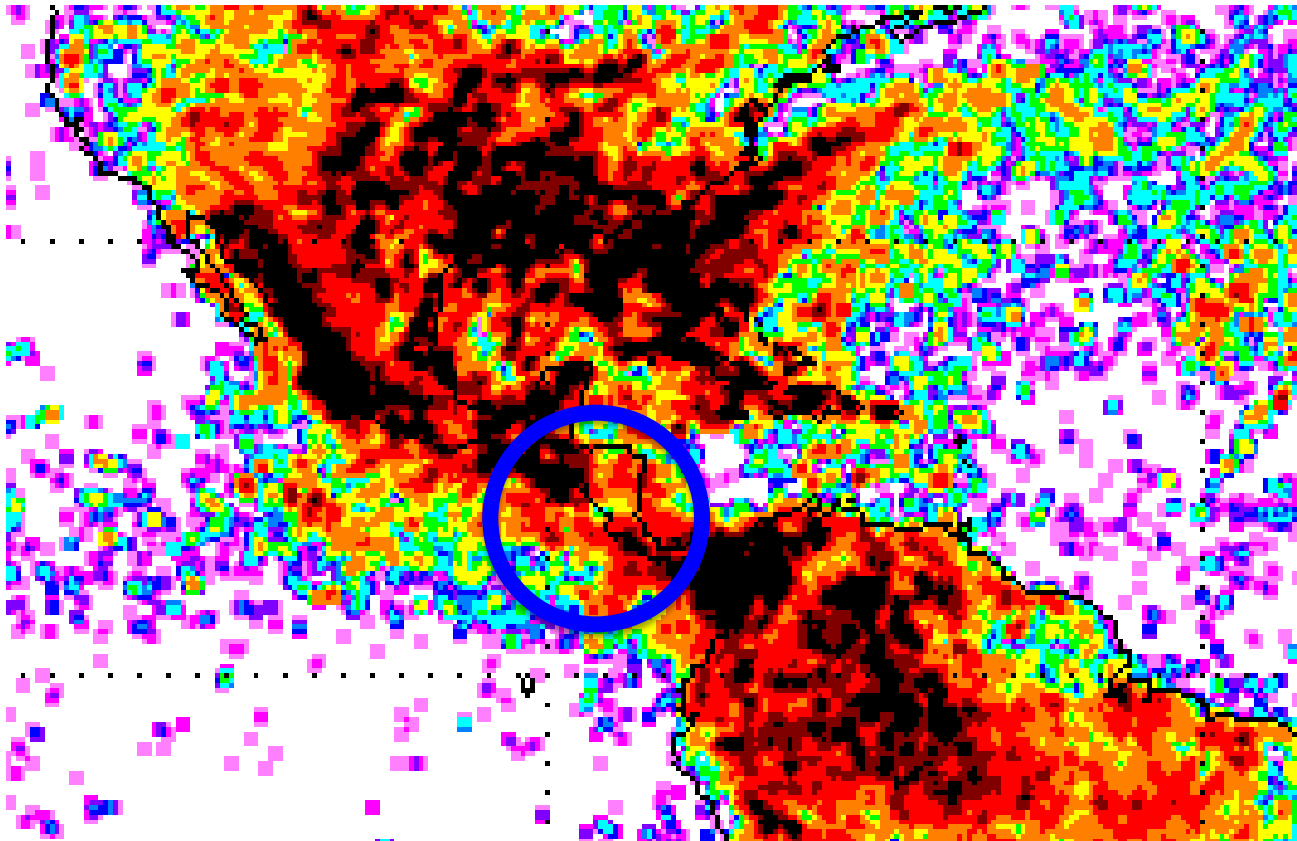
What if all lightning produce TGFs



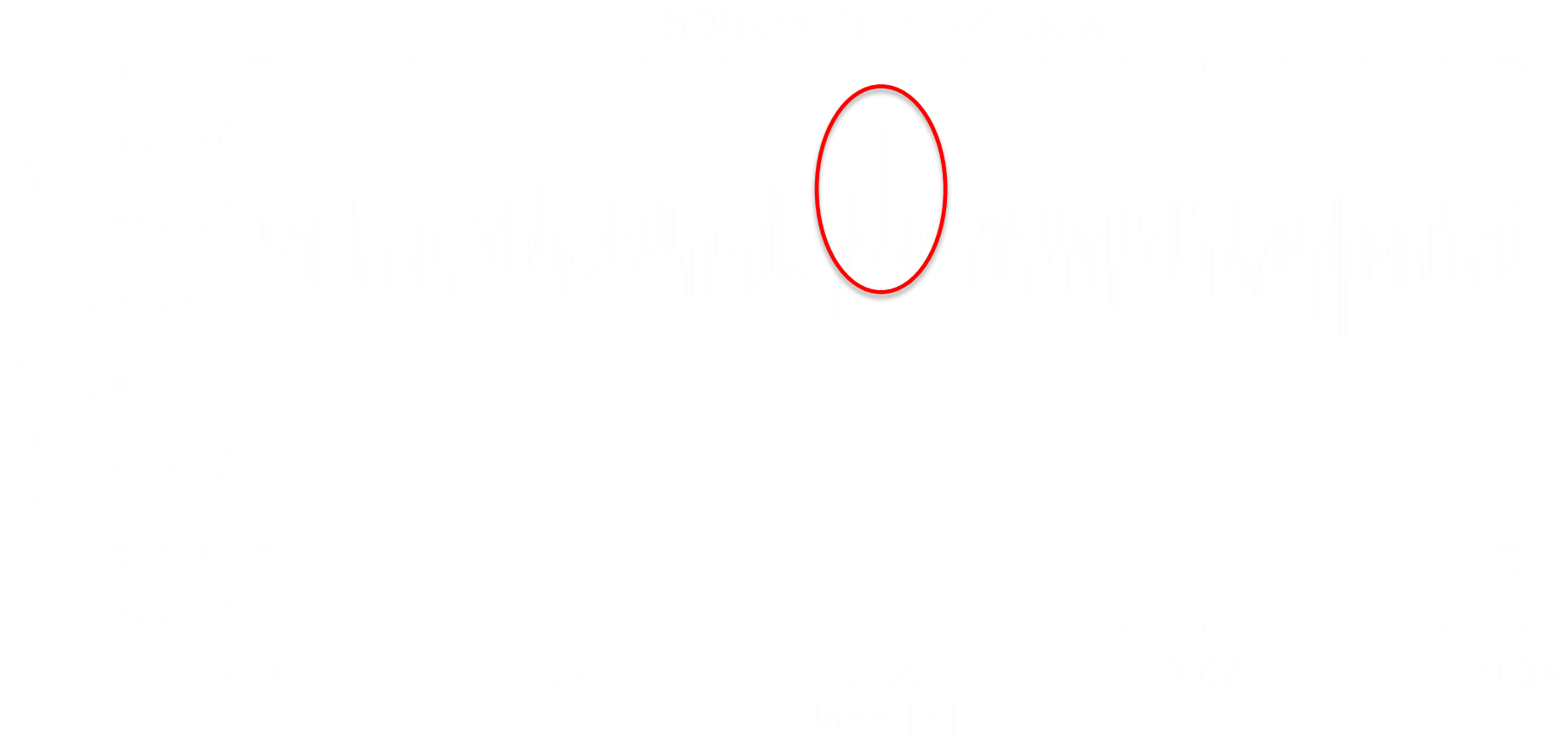
45 lightning pr second – 4 million pr day
Are TGFs also common? (Østgaard et al., 2012)

Project by master student Kjetil Albrechtsen

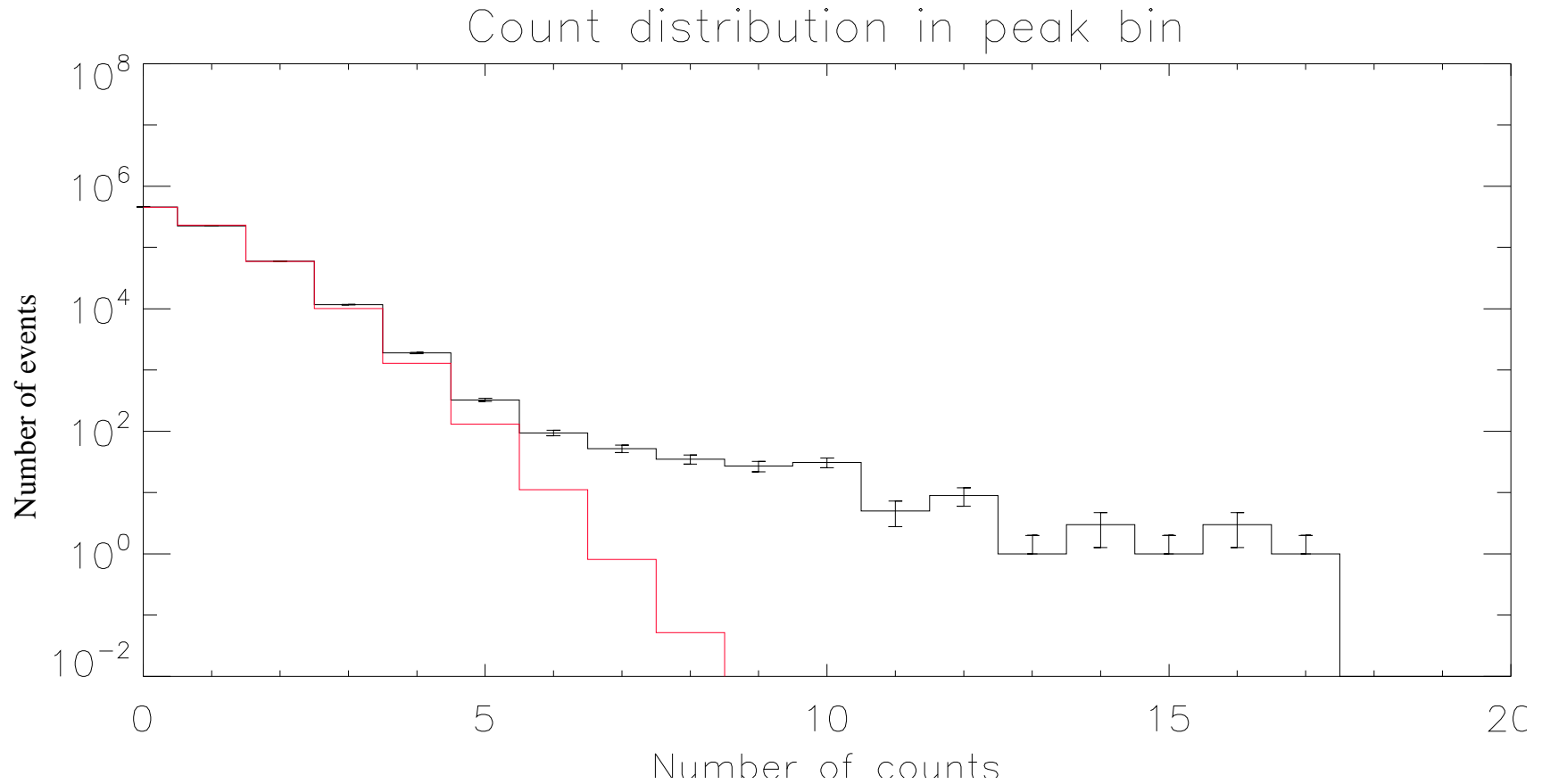
Use WWLLN time tags of lightning occurring within 800km of RHESSI footprint. Superimpose continuous (~0.1s string) RHESSI data and check for an emerging signal.



760 000 lightning from the 2006 and the 2012 WWLLN dataset.
Peak of 5 sigma (Poisson) relative to the background



A new set of approx 100 TGFs!



Charging the cloud

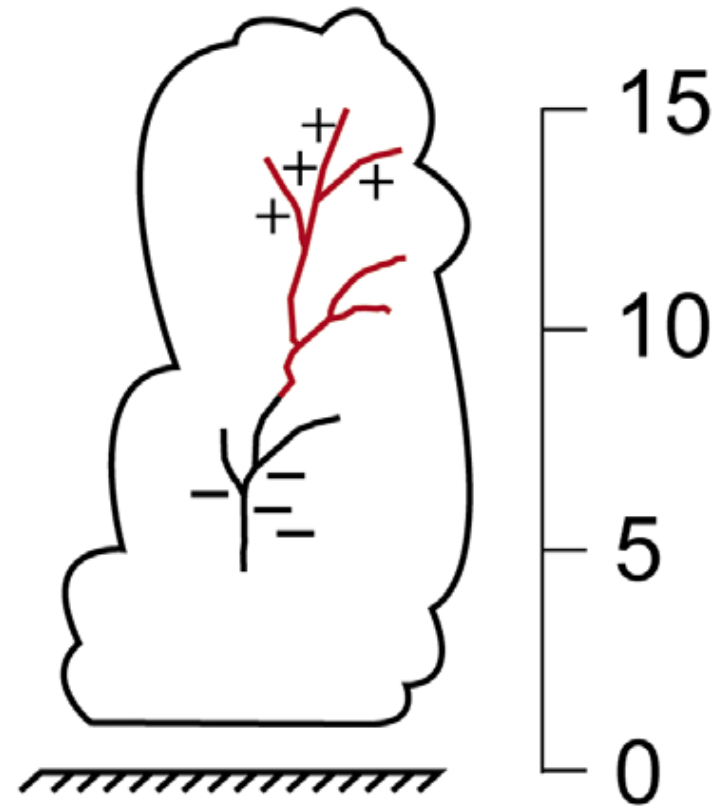
Leader forms from the negative charge layer

Leader short-cuts the negative and positive poles

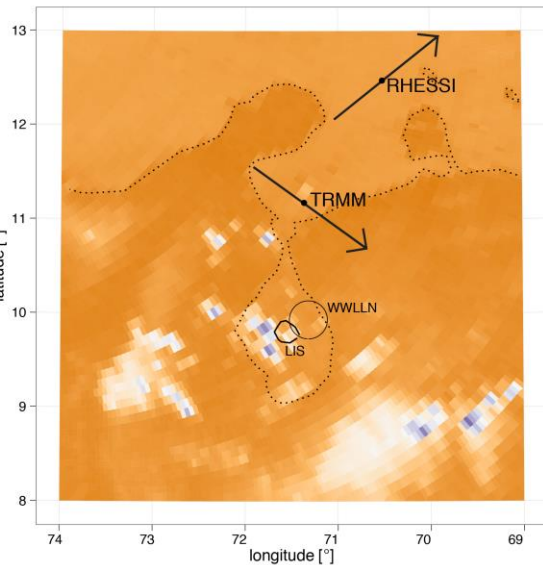
Bright visible lightning

Thunder

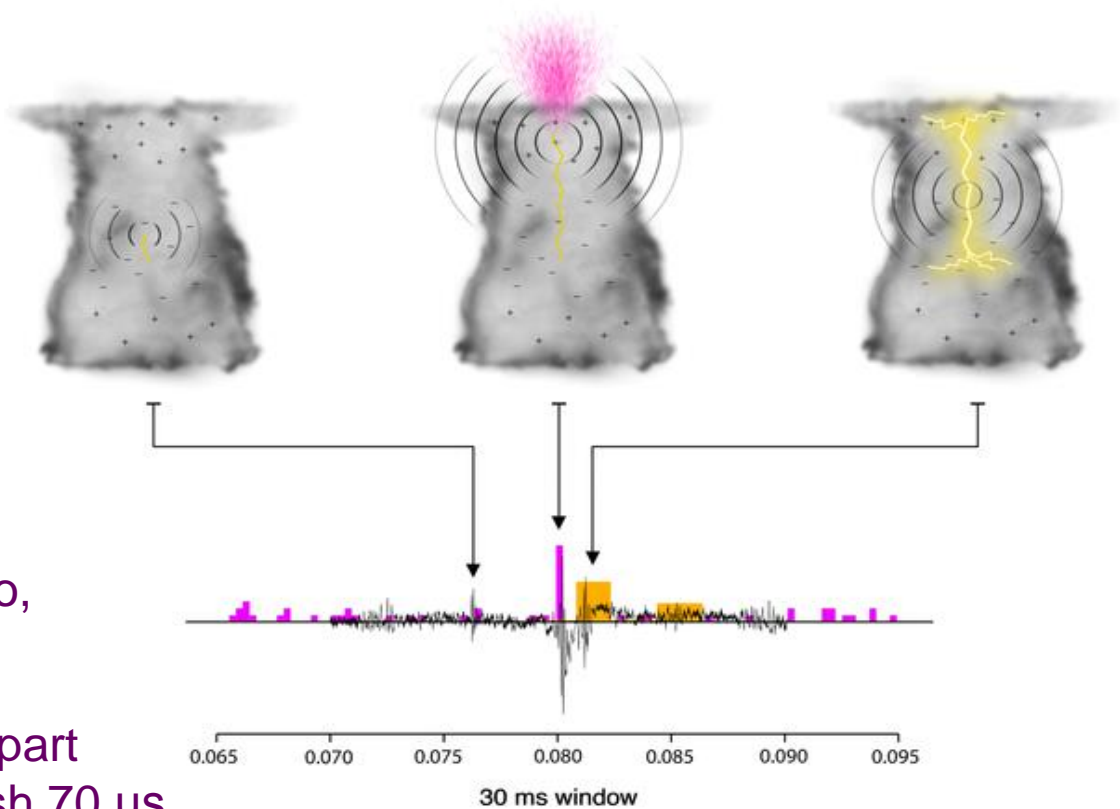
When and how
is gamma produced?



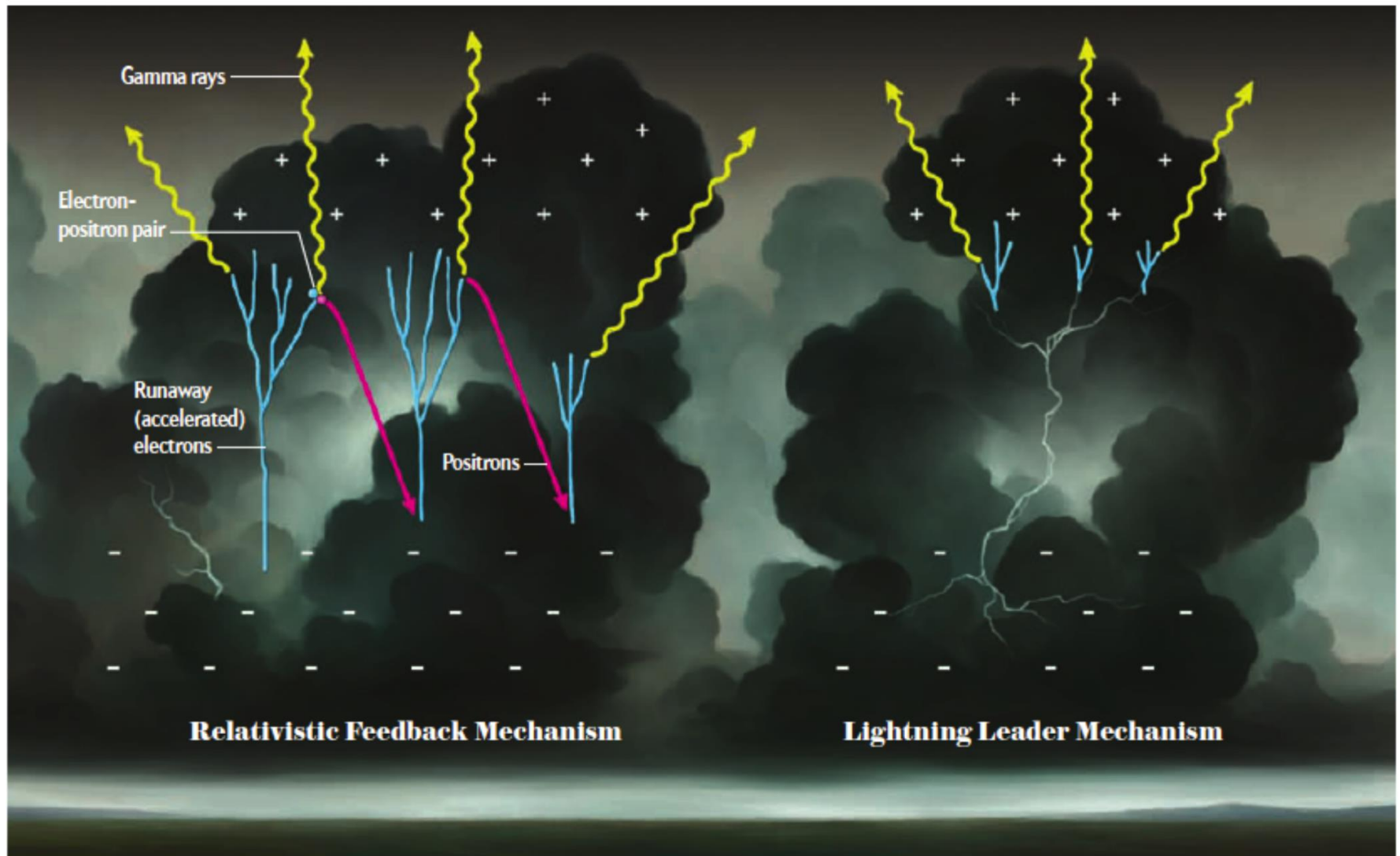
Østgaard et al., 2013 – AGU press release – April 2013



- Lightning Lake Maracaibo, Venezuela
- Two satellites < 300 km apart
- Terrestrial gamma-ray flash 70 μ s
- Two radio measurements
- Sequence: Initiation(duke), VLF(duke -TGF), Optical/VLF (LIS/duke – return stroke)

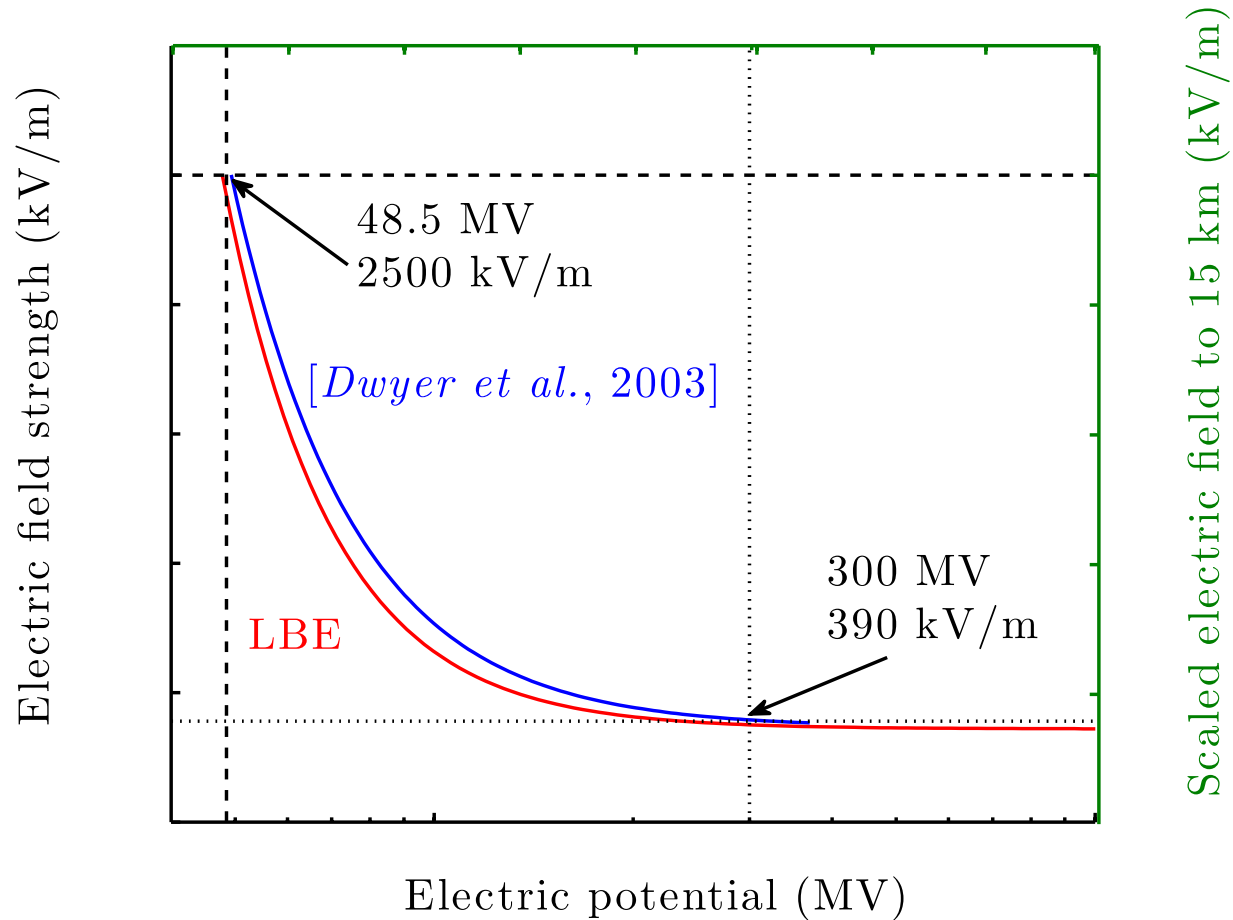


What are the production mechanisms?

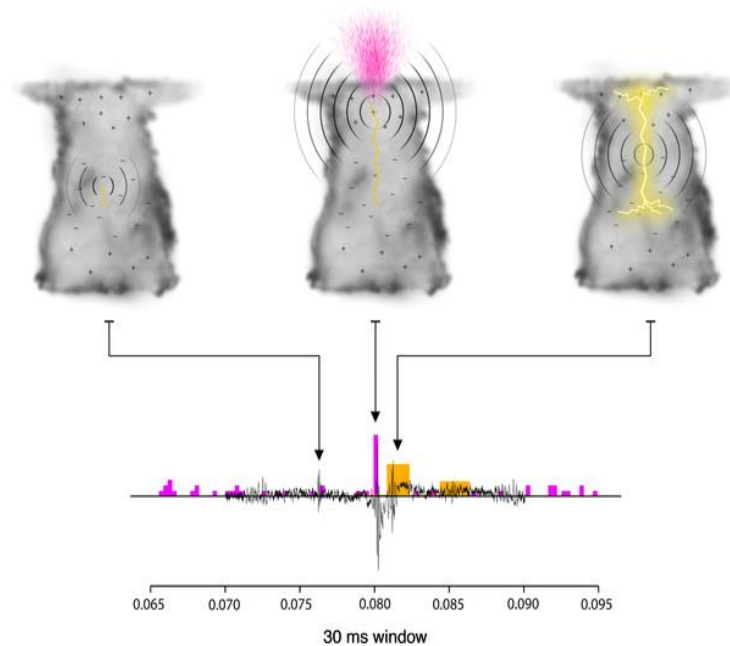
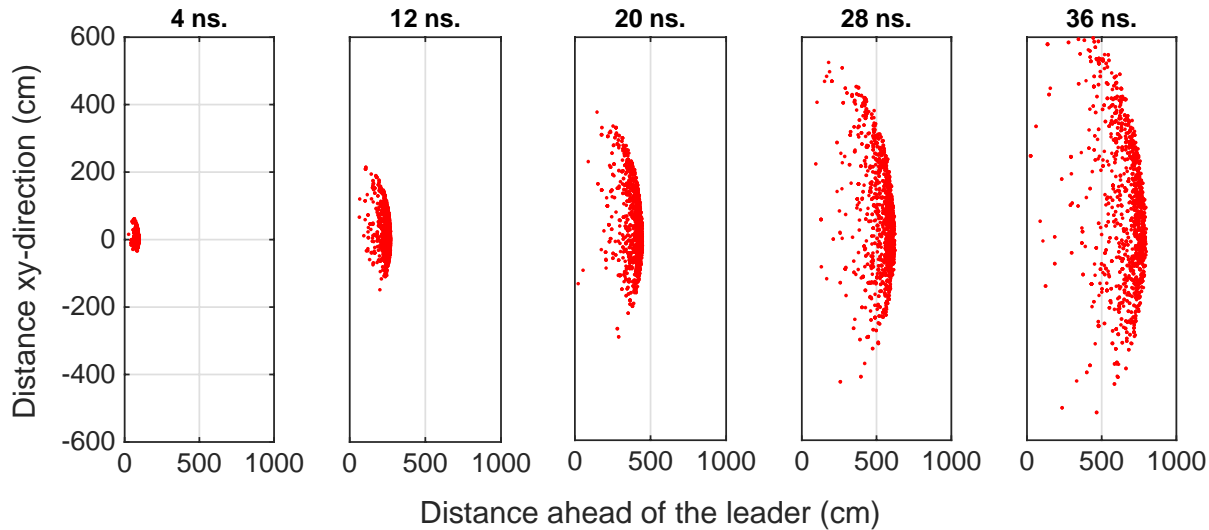


[Broberg Skeltved, et Al. 2014]

Vertical extention of electric field at 15 km (km)



Thermal acceleration in streamer/leader fields.



- Birkeland Centre for Space Science – a healthy 2 year old centre
- A very large community that participates in a wide range of projects:
 - ASIM,
 - Detailed analysis of satellite and ground measurements (radiowave - ULF,VLF,VHF..),Particle/gamma,
 - Computer modeling,
 - Laboratory experiments,
 - Aircraft – in-flight measurements