

# Lightning Research at Säntis Tower

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<http://emc.epfl.ch>



# EMC (Electromagnetic Compatibility) Lab

<http://emc.epfl.ch>



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### Welcome to the Electromagnetic Compatibility Laboratory (EMC Lab)

The EMC Laboratory of the Swiss Federal Institute of Technology is active in EMC research since early 1980s. Our Research is essentially sponsored by various programs of Swiss National Science Foundation, European Community, Swiss Electrical Utilities (PSEL, CREE-RDP), as well as by private companies.

We collaborate with many international research centers and universities among which Universities of Bologna and Rome (Italy), University of Toronto (Canada), University of Florida (USA), Radio Research and Development Institute (Russia), etc.

Students at Swiss Federal Institute of Technology have an opportunity to get involved in EMC research through semester projects (undergraduate level), diploma projects (equivalent to MS), and

### HIGHLIGHT

[Good waves for saving lives](#)  
[Lightning does actually strike in the same place twice!](#)  
[NEW BOOK: Electromagnetic Field Interaction with Transmission Lines](#)

### CONTACT

#### Electromagnetic Compatibility Laboratory



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# International Union of Radio Science (URSI)

- **URSI is a non-governmental and non-profit organisation under the International Council for Science**
- **Stimulating and co-ordinating, on an international basis, studies, research, applications, scientific exchange, and communication in the fields of radio science.**
- **Active since 1922**
- **<http://ursi.org>**

# URSI Scientific Commissions

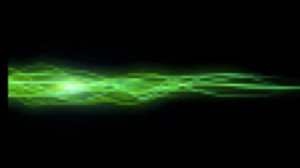
## Commission A

Electromagnetic  
Metrology



## Commission B

Fields and waves



## Commission C

Radiocommunication  
Systems and Signal  
Processing



## Commission D

Electronics and  
Photonics



## Commission E

Electromagnetic  
Environment and  
Interference



## Commission F

Wave Propagation  
and Remote  
Sensing



## Commission G

Ionospheric Radio  
and Propagation



## Commission H

Waves in Plasmas



## Commission J

Radio Astronomy



## Commission K

Electromagnetics in  
Biology and  
Medicine



# Swiss Experimental Station on Lightning Research at Mount Säntis

Funding: Swiss National Science Foundation

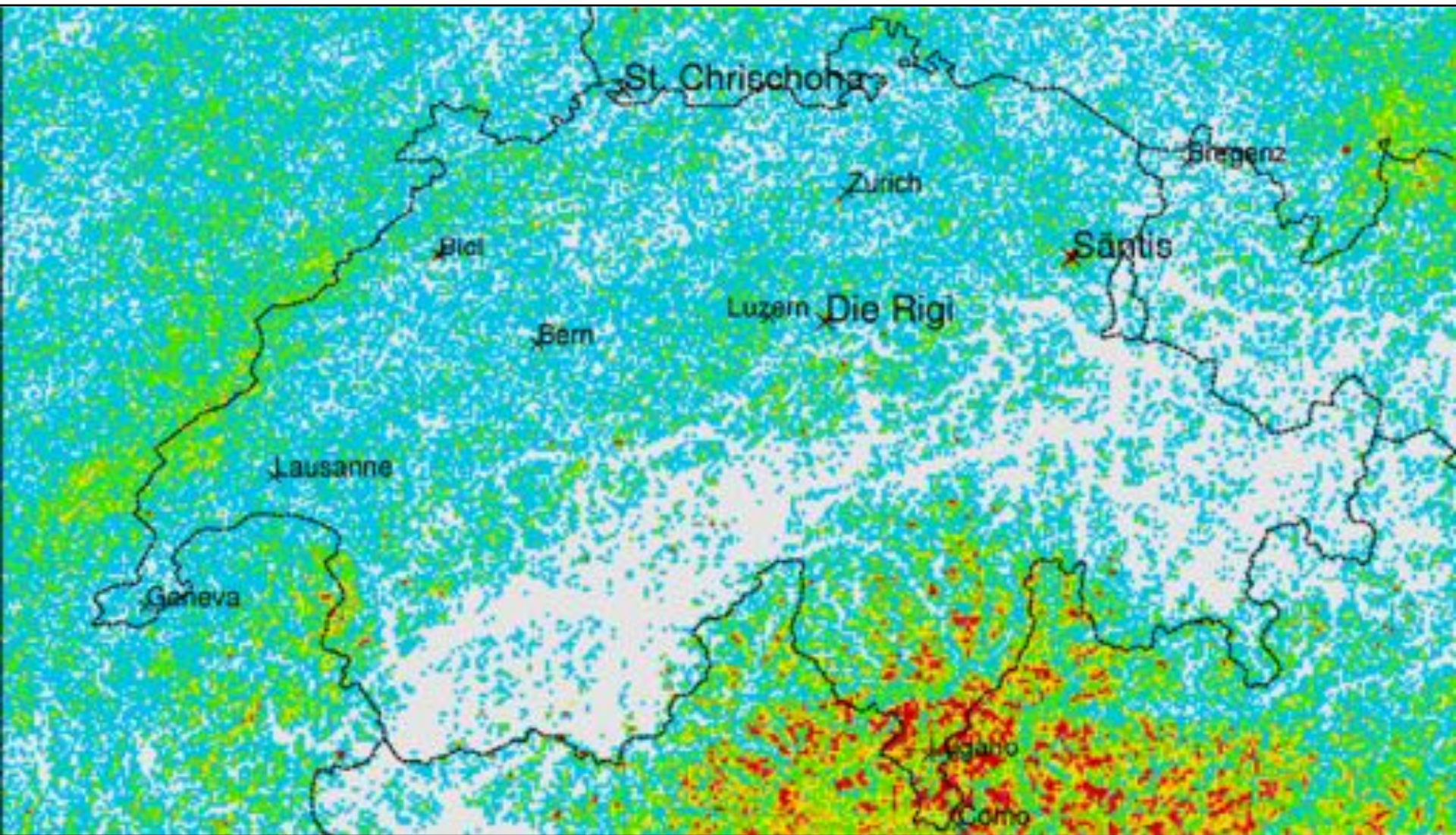
- The Säntis Tower is one of the hotspot of lightning activities in Europe.
- It is instrumented for lightning current measurement since June 2010.
- Since then, over 500 lightning flashes were successfully recorded.



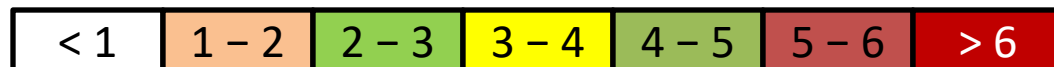
# Swiss Experimental Station on Lightning Research at Mount Säntis



# Lightning flash density in Switzerland



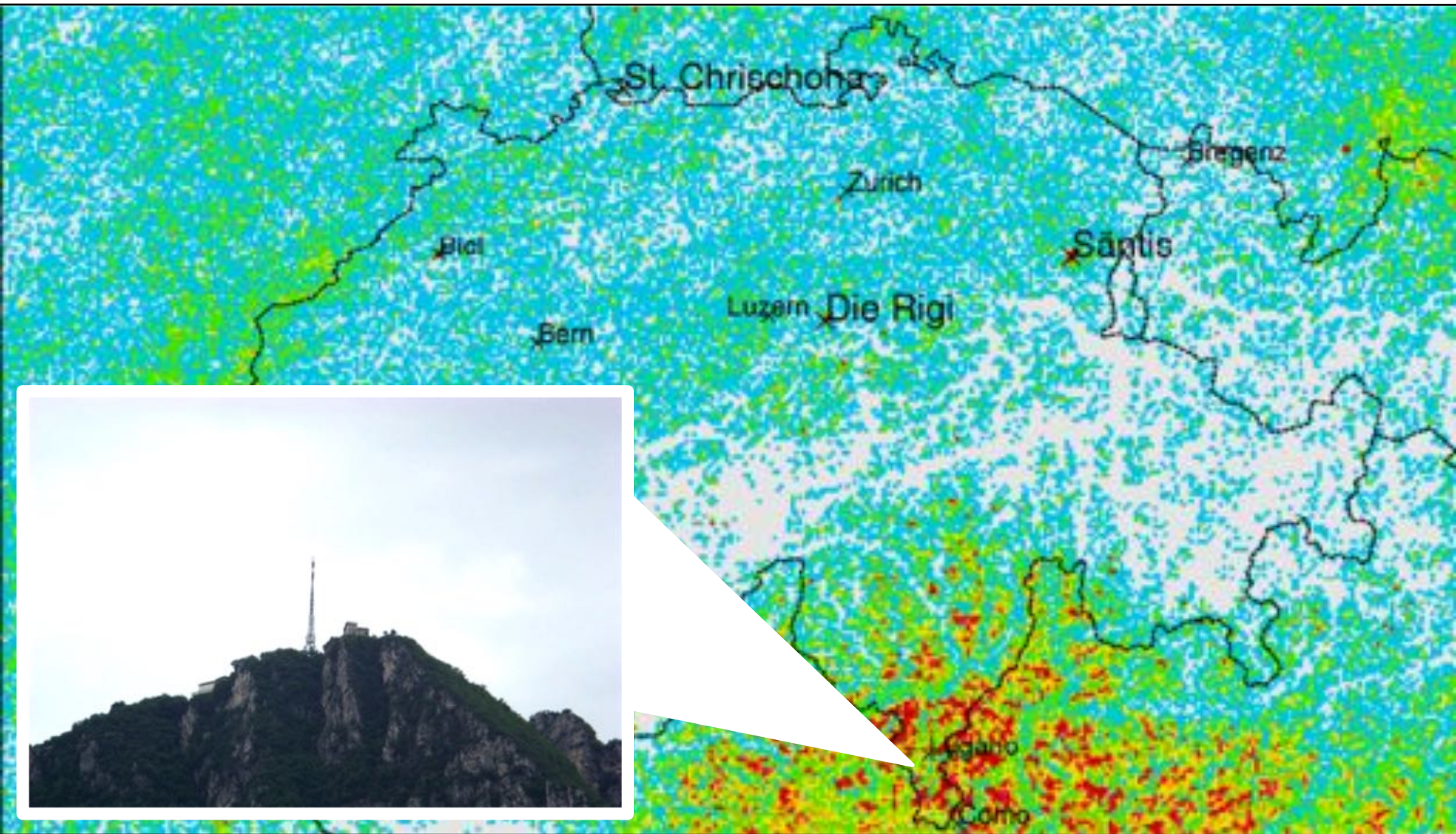
Flashes  
 $\text{km}^2 \cdot \text{year}$



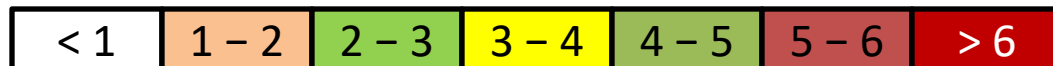
Source: EUCLID, observation period: 01/1999 - 12/2006



# Lightning flash density in Switzerland



Flashes  
 $\text{km}^2 \cdot \text{year}$



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# History: Berger's Tower Measurements at Monte San Salvatore

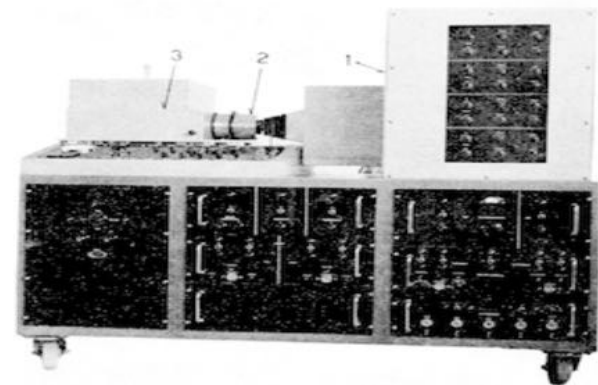
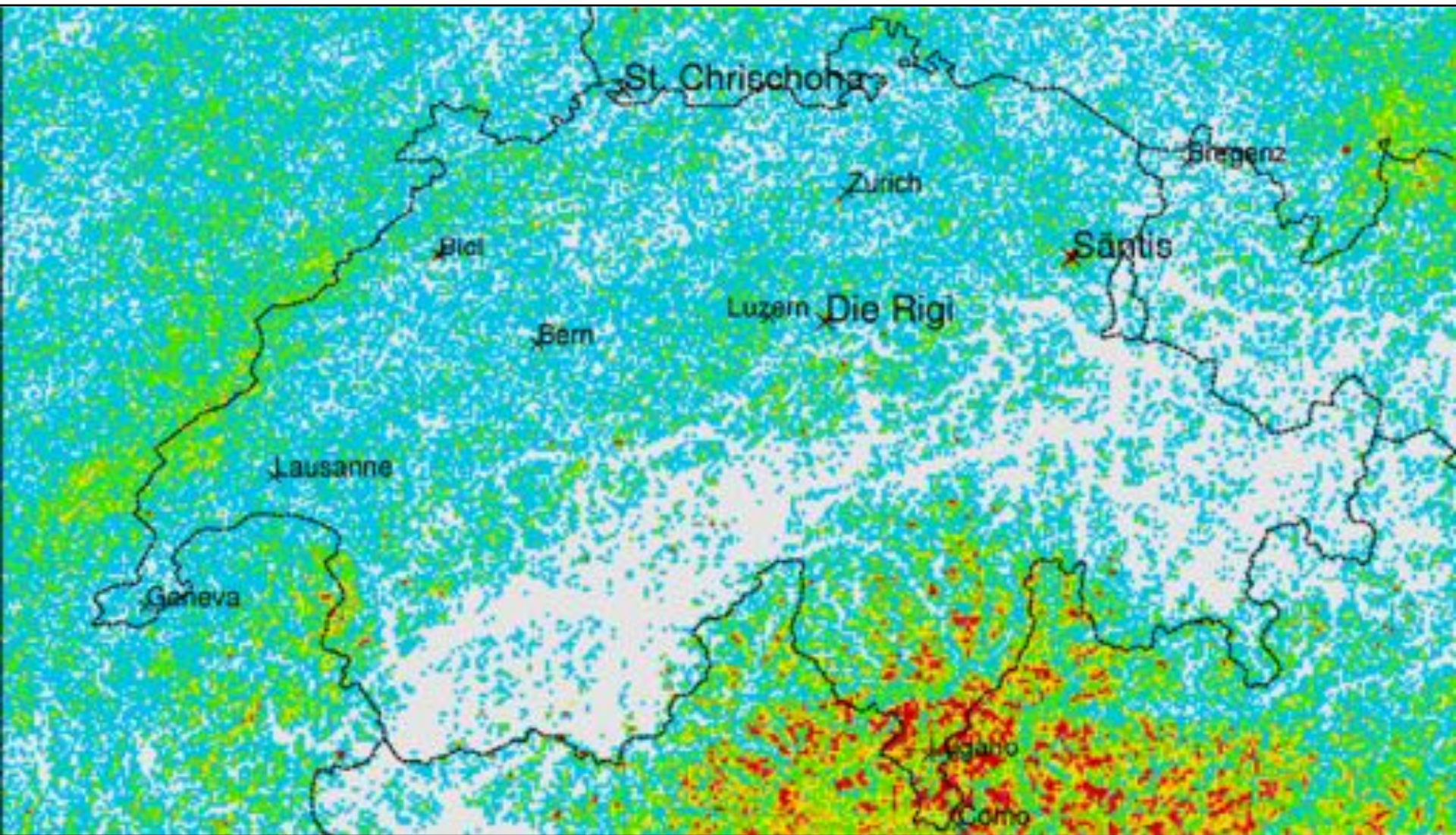


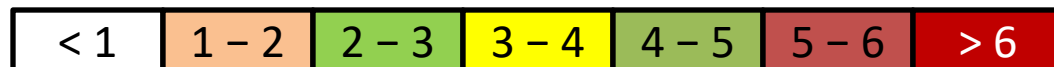
Fig. 6



# Lightning flash density in Switzerland



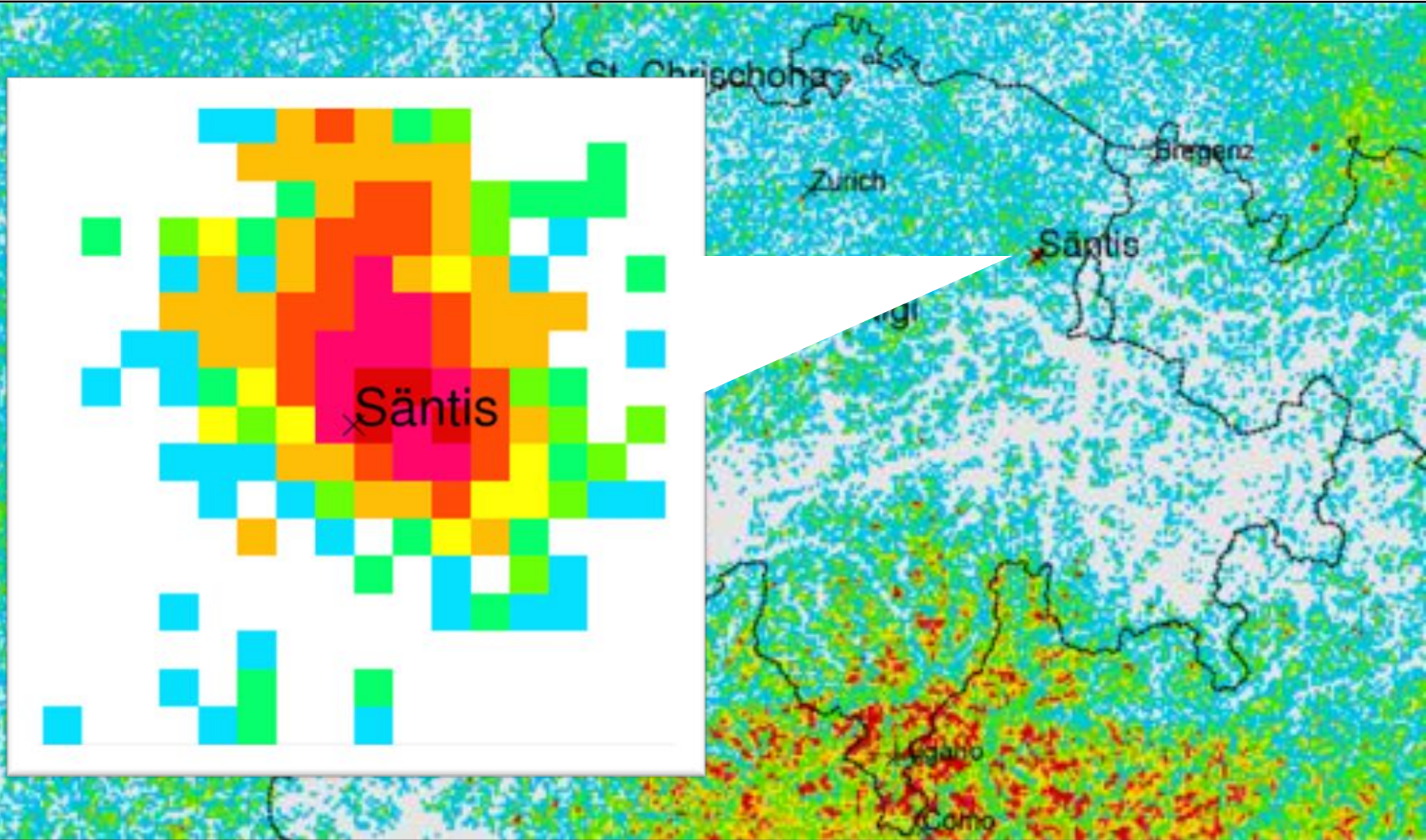
Flashes  
 $\text{km}^2 \cdot \text{year}$



Source: EUCLID, observation period: 01/1999 - 12/2006



# Lightning flash density in Switzerland



Flashes  
 $\text{km}^2 \cdot \text{year}$



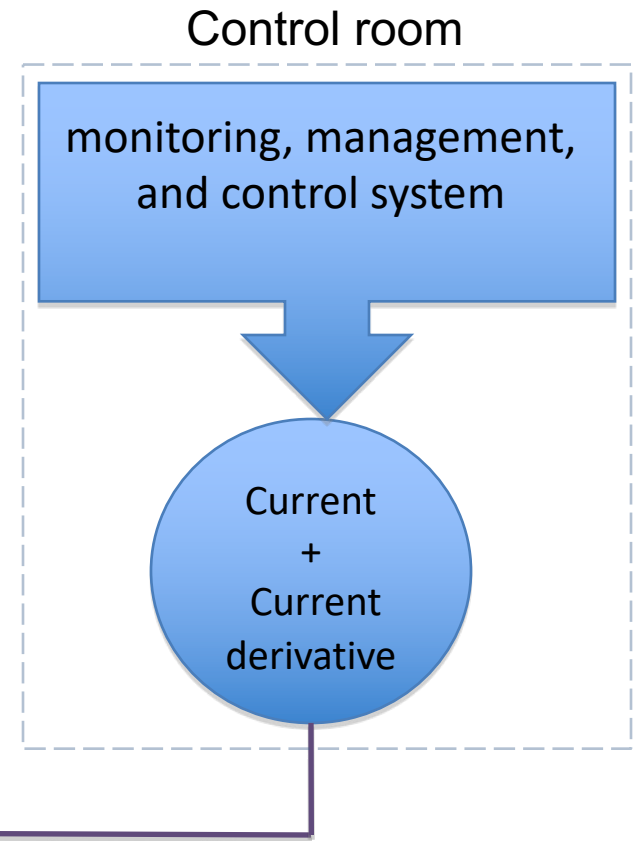
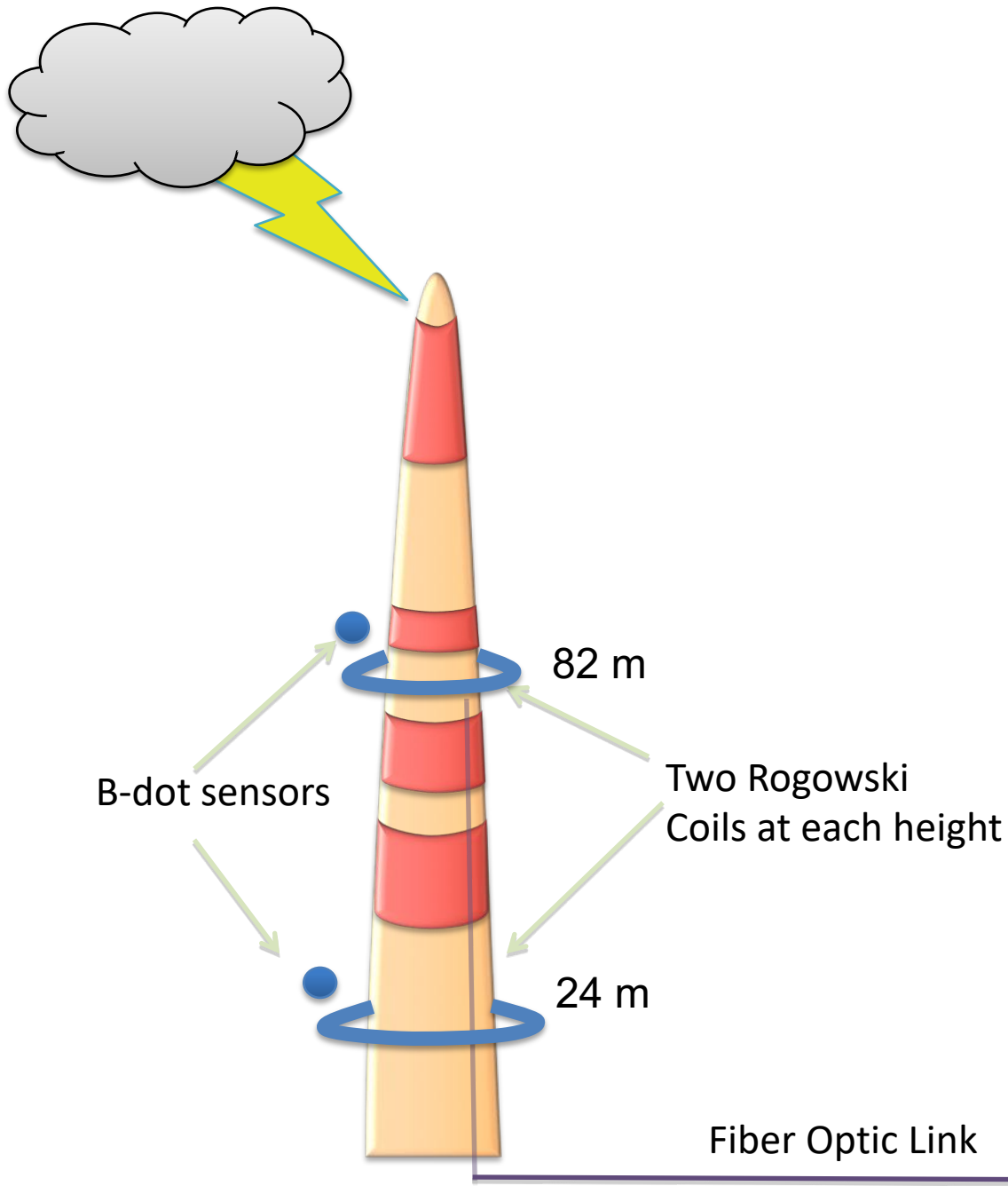
Source: EUCLID, observation period: 01/1999 – 12/2006



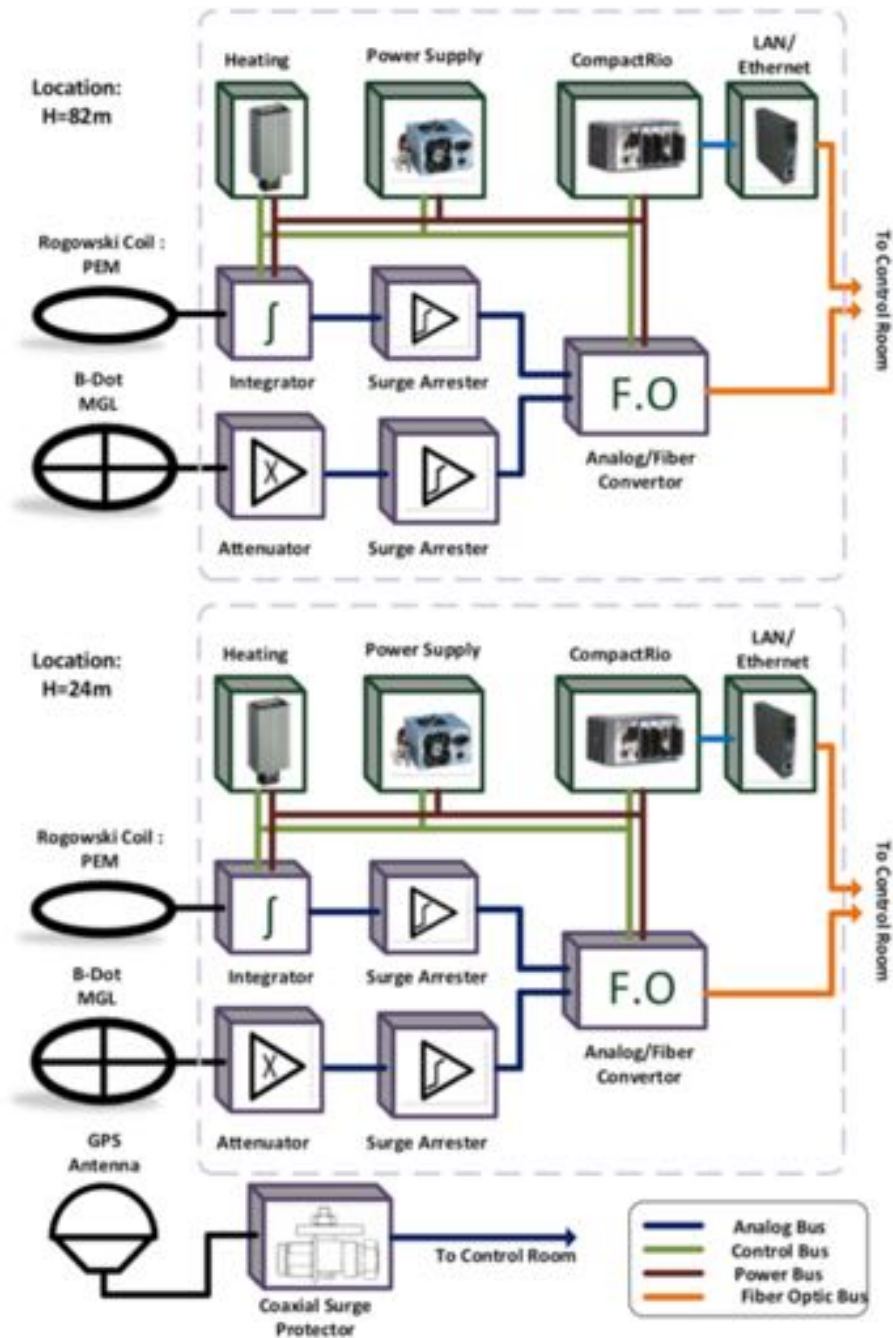
**2011**

**Säntis mountain: 2502 m; Säntis Tower: 123.5 m**



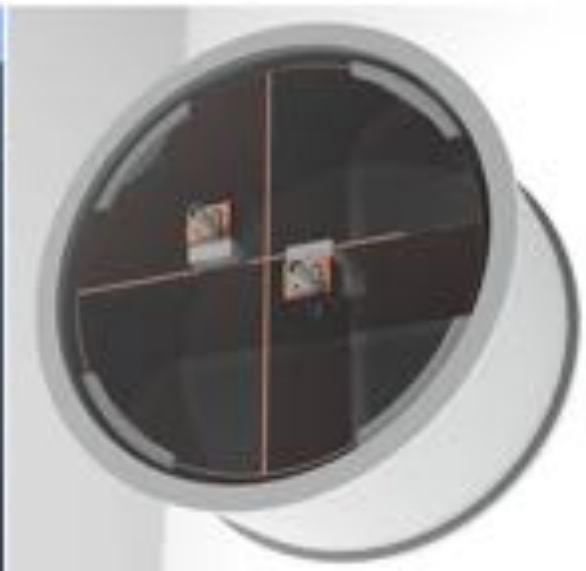
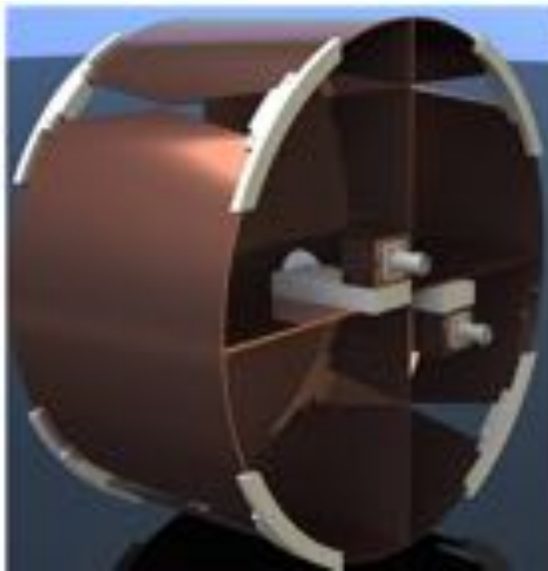


# Tower





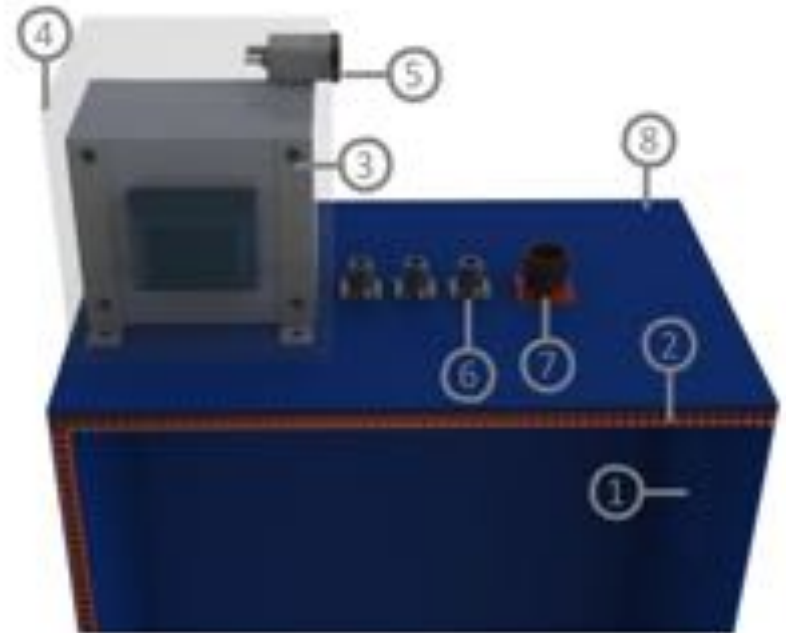
# B-Dot Multigap Sensor



# EMC Box Design



1. Metal enclosure
2. Input connectors
3. Rogowski integrators
4. Power adapters
5. Power supply
6. Analog / Fiber system
7. Surge peak arresters
8. CompactRio
9. Ethernet / Fiber LAN
10. Heating system
11. Isolation transformer
12. System FAN
13. Fiber input connector
14. Insulation material



1. Honeycomb fan pattern
2. Beryllium copper finger gasket
3. Isolation transformer
4. Stainless steel transformer box
5. Input filter connector
6. Input connectors
7. Fiber pass hole HF filter
8. Stainless steel metal box

# Equipment Installation





# Equipment Installation



# Equipment Installation



*B-Dot installed along with Rogowski Coils*



*View of the tower*



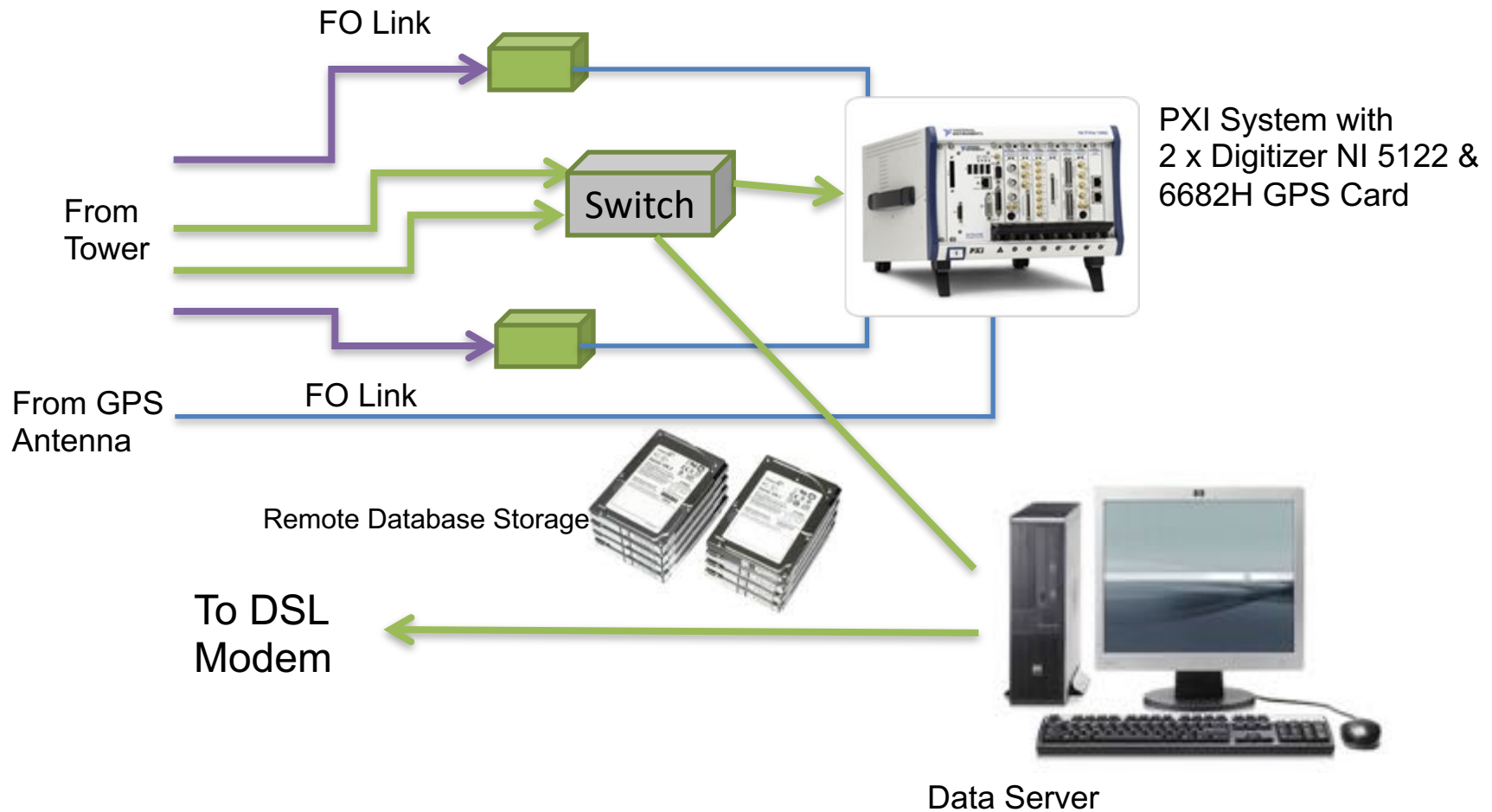
# Recent updates

- Installation of isolation transformers
- Installation of UPS
- Software upgrade





# Control Room



Maintenance, monitoring and control tasks can be carried out remotely using a remote control system over the Internet using a standard DSL link on the Sántis

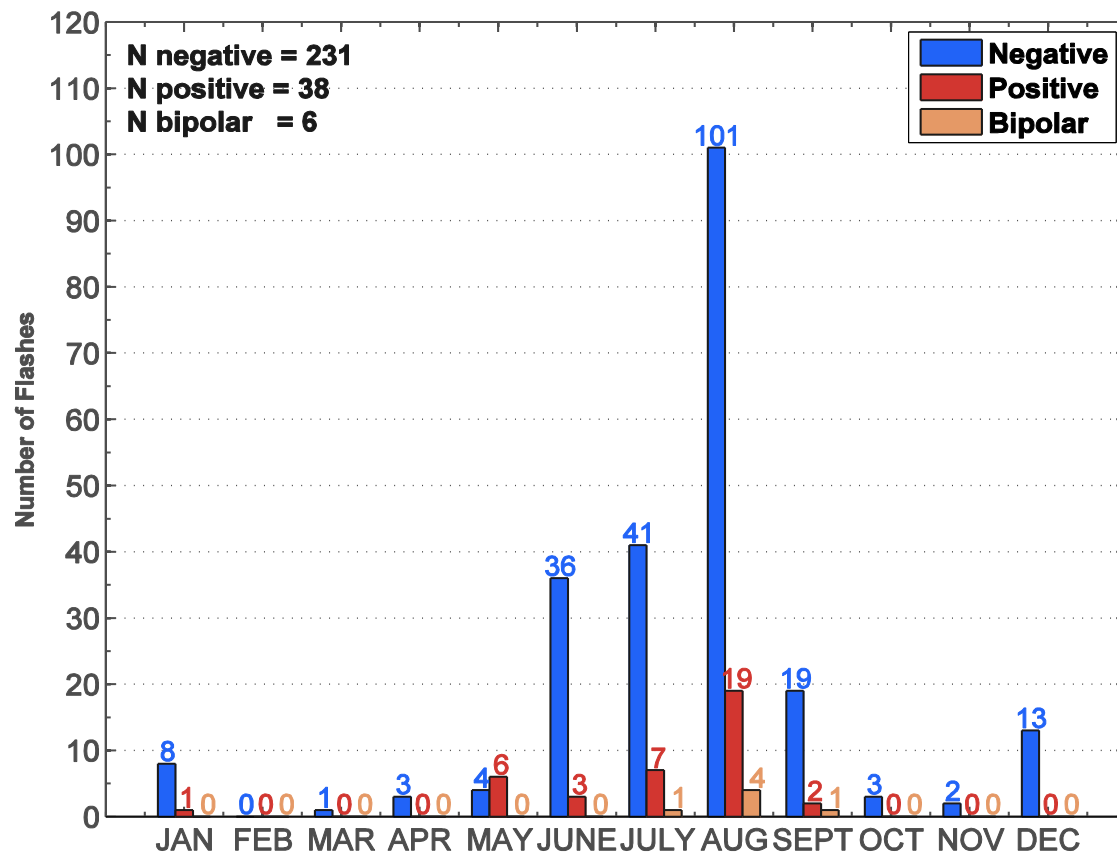
# Obtained Data

- From 19 May 2010, about **500** flashes were successfully recorded on the Säntis.



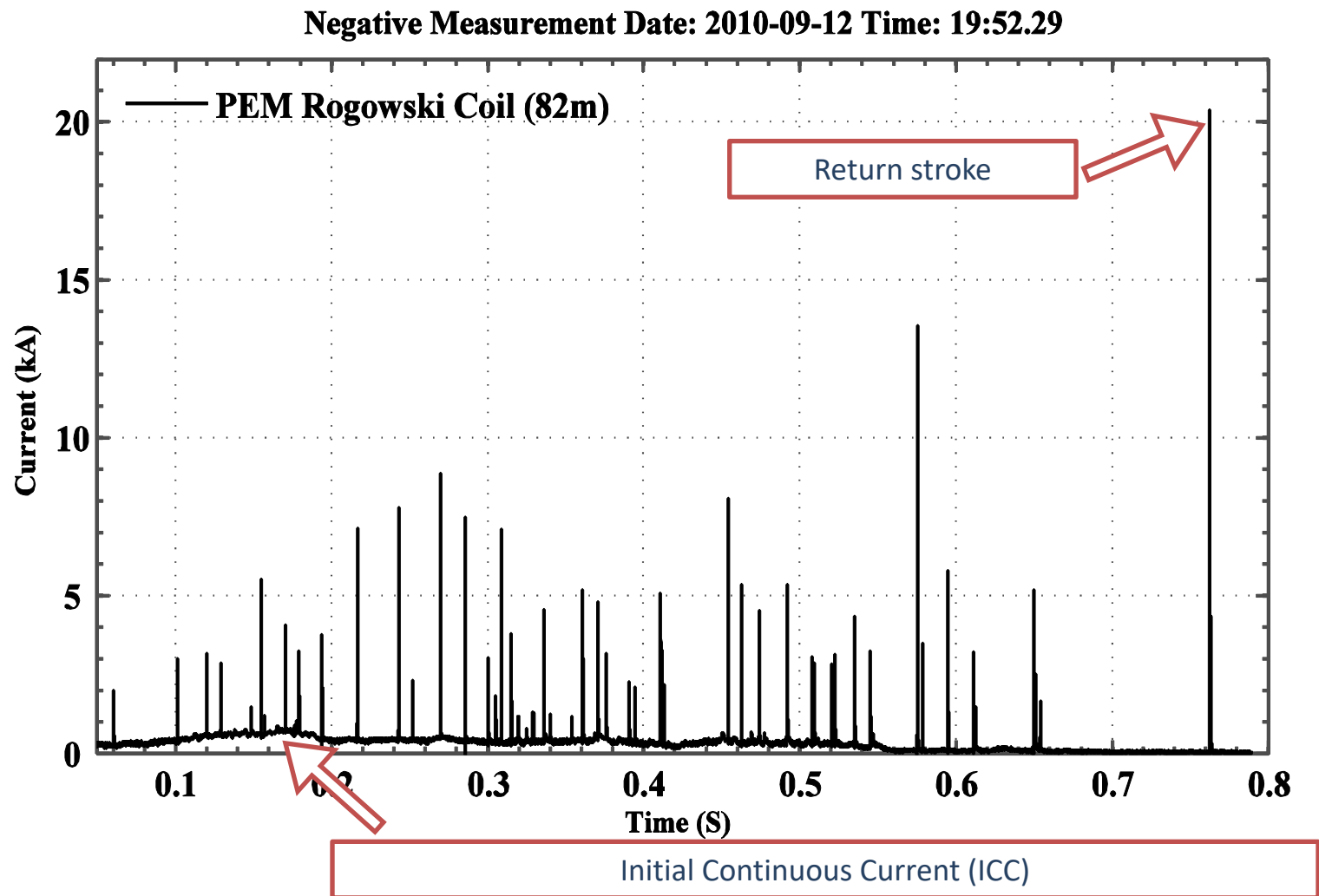
# Obtained Data: Negative Flashes

Monthly flash count to the Säntis tower, recorded in the period from May2010 to January 2013



# Gathered Data

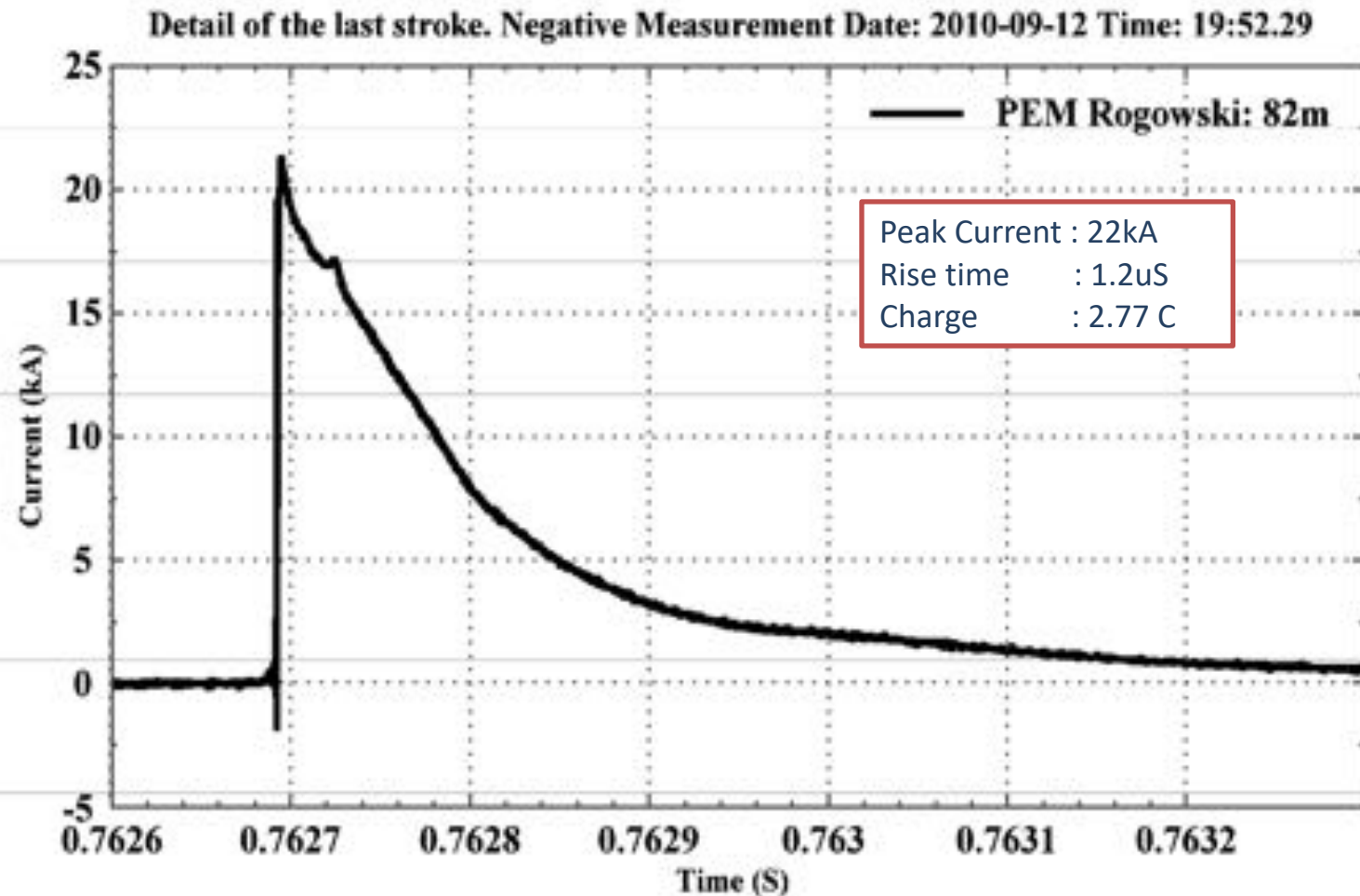
## Example of a Negative Flash





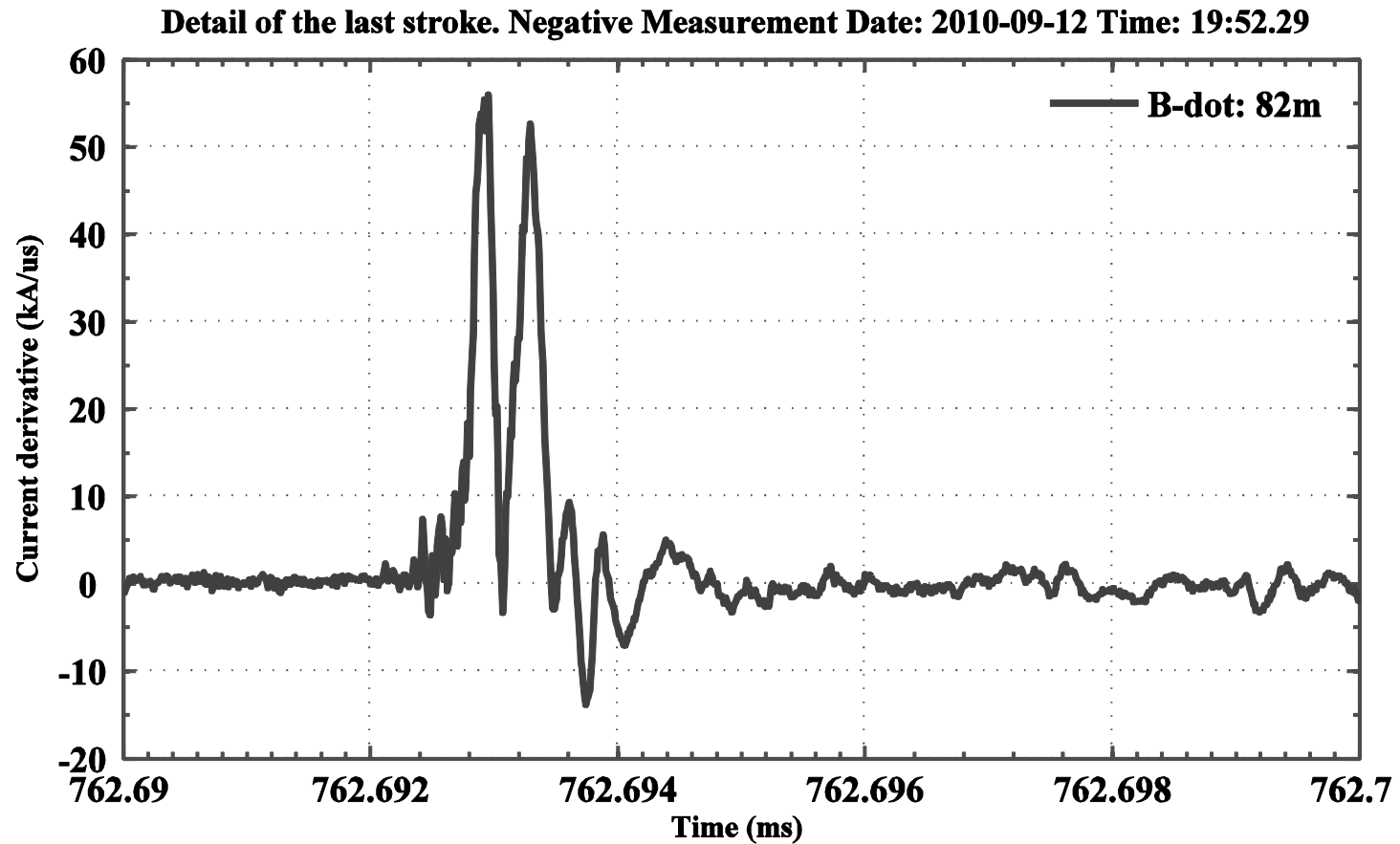
# Gathered Data

## Example of a Negative Flash: Detail



# Example of a Negative Flash

## $di/dt$



# Upward Negative Flashes: Peak Current

STATISTICAL PARAMETERS OF PEAK CURRENT

Peak current (kA)						
Tower	Sample size	Percentage Exceeding Tabulated Value				
		95%	90%	50%	10%	5%
Empire State Building [19]	82	-	4	5	10	-
San Salvatore [20]	176	-	4.2	10	25	-
Moscow Ostankino Tower [22] <sup>◇</sup>	58	-	4	9	19	-
Peissenberg [21]*	125	-	-	8.5	-	20
CN Tower [17] <sup>◇</sup>	387	1.3	-	5.1	-	16
Gaisberg Tower [5] <sup>#</sup>	476	3.5	4.2	9.2	18	22
Säntis (This study)	1987	2.9	3.4	6.4	11.9	14.1

<sup>◇</sup> Measurements at 533 m above ground

\* for ICC pulses and return-stroke pulses

<sup>#</sup> Current pulses underwent a 250-kHz low pass filtering

# Positive Flashes

- Positive flashes are of particular interest for a number of reasons, most importantly:
  - (1) They are characterized by high peak currents and large impulse charges.



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(1) They are characterized by high peak currents and large impulse charges.

- ✓ They are a major concern for the designers of lightning protection systems of structures such as wind turbines and telecommunication towers.

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  - (2) Their EM field waveforms are characterized by a complex structure.

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  - (1) They are characterized by high peak currents and large impulse charges.
  - (2) Their EM field waveforms are characterized by a complex structure.
    - ✓ Hard to detect and classify by lightning location systems

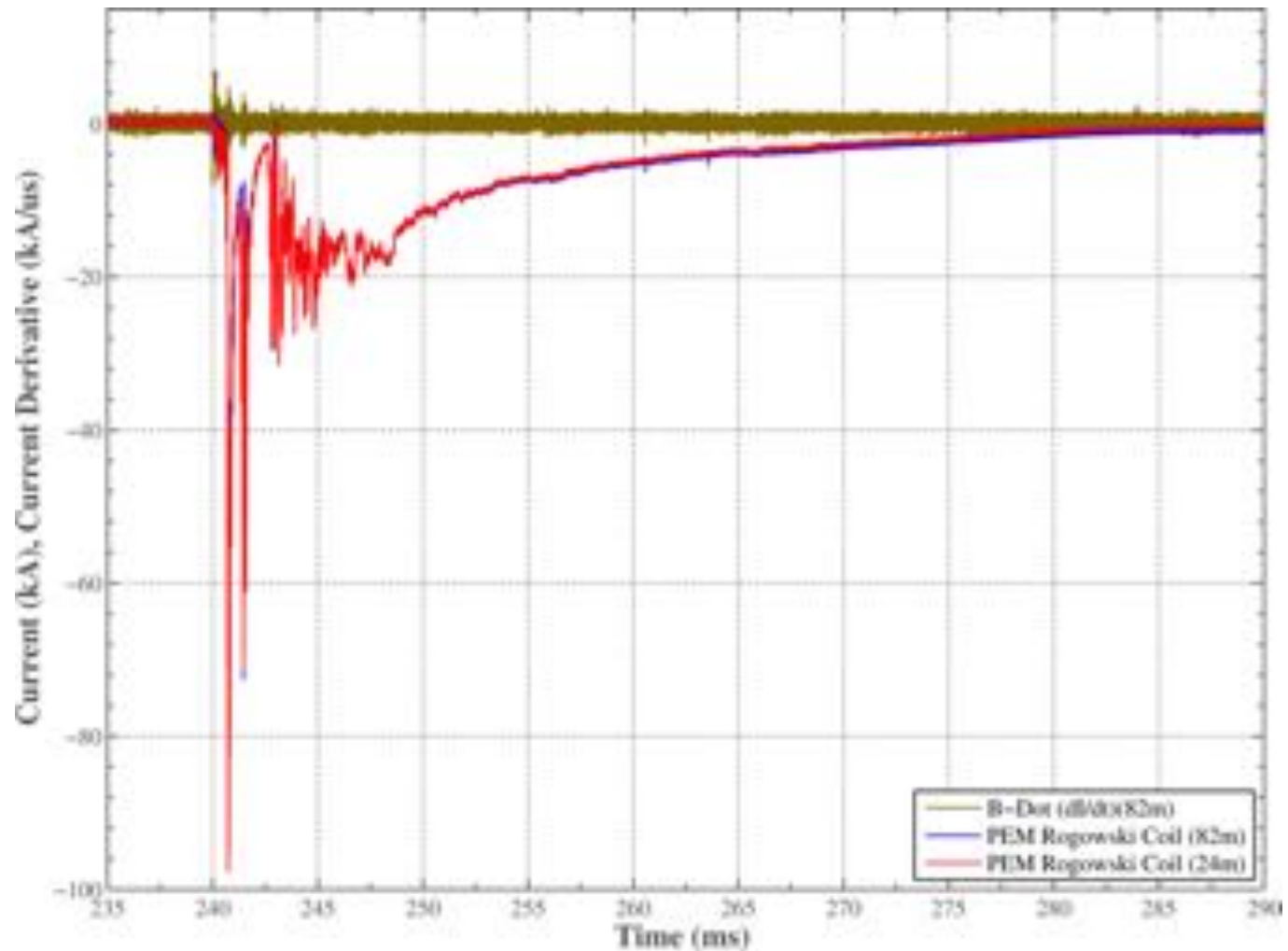
# Positive Flashes

- Positive flashes are of particular interest for a number of reasons, most importantly:
  - (1) They are characterized by high peak currents and large impulse charges.
  - (2) Their EM field waveforms are characterized by a complex structure.
  - (3) They are related to the initiation of transient luminous events in the middle atmosphere.



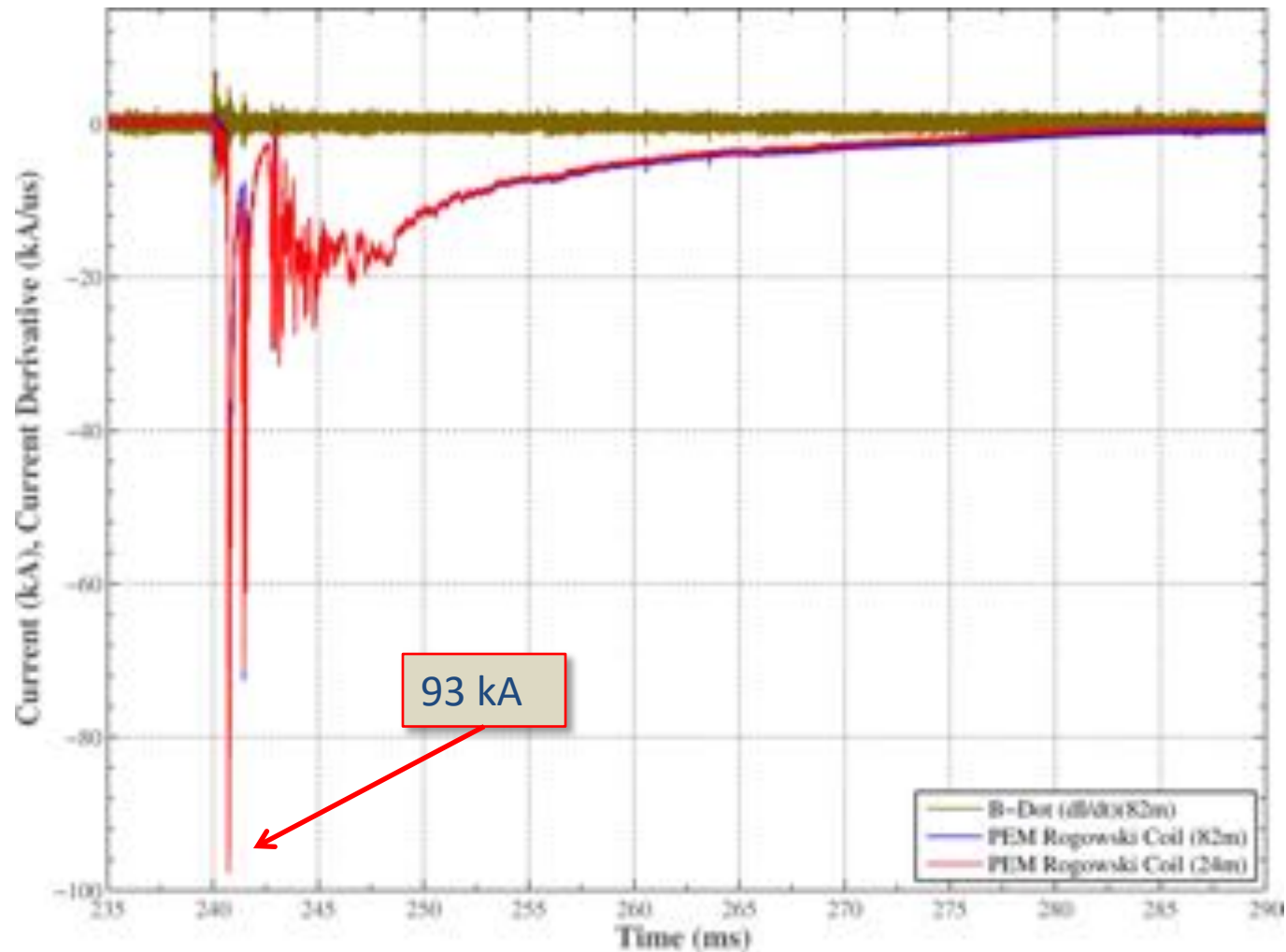
# Example of a Positive Flash

August 27, 2011



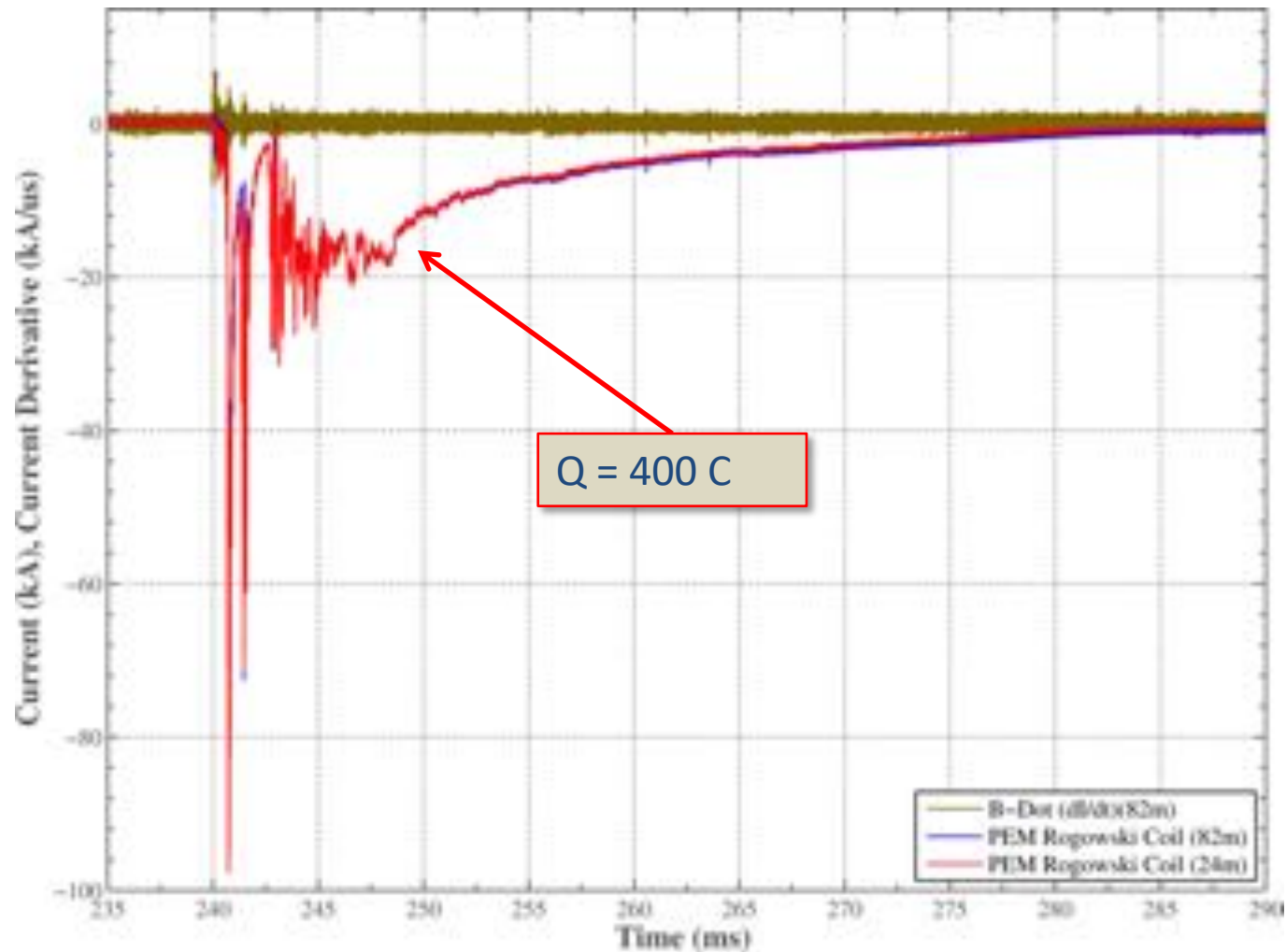
# Example of a Positive Flash

August 27, 2011



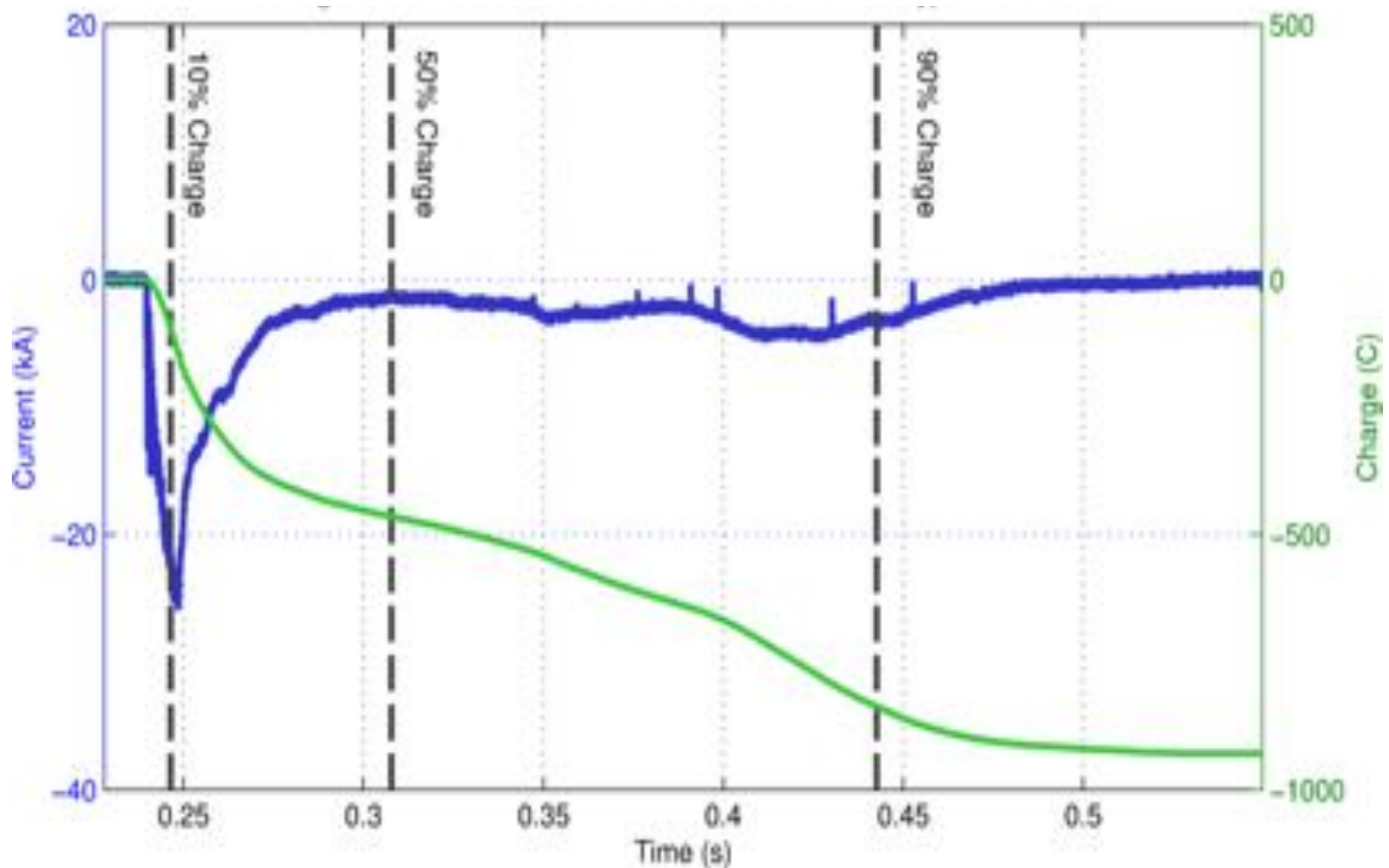
# Example of a Positive Flash

August 27, 2011



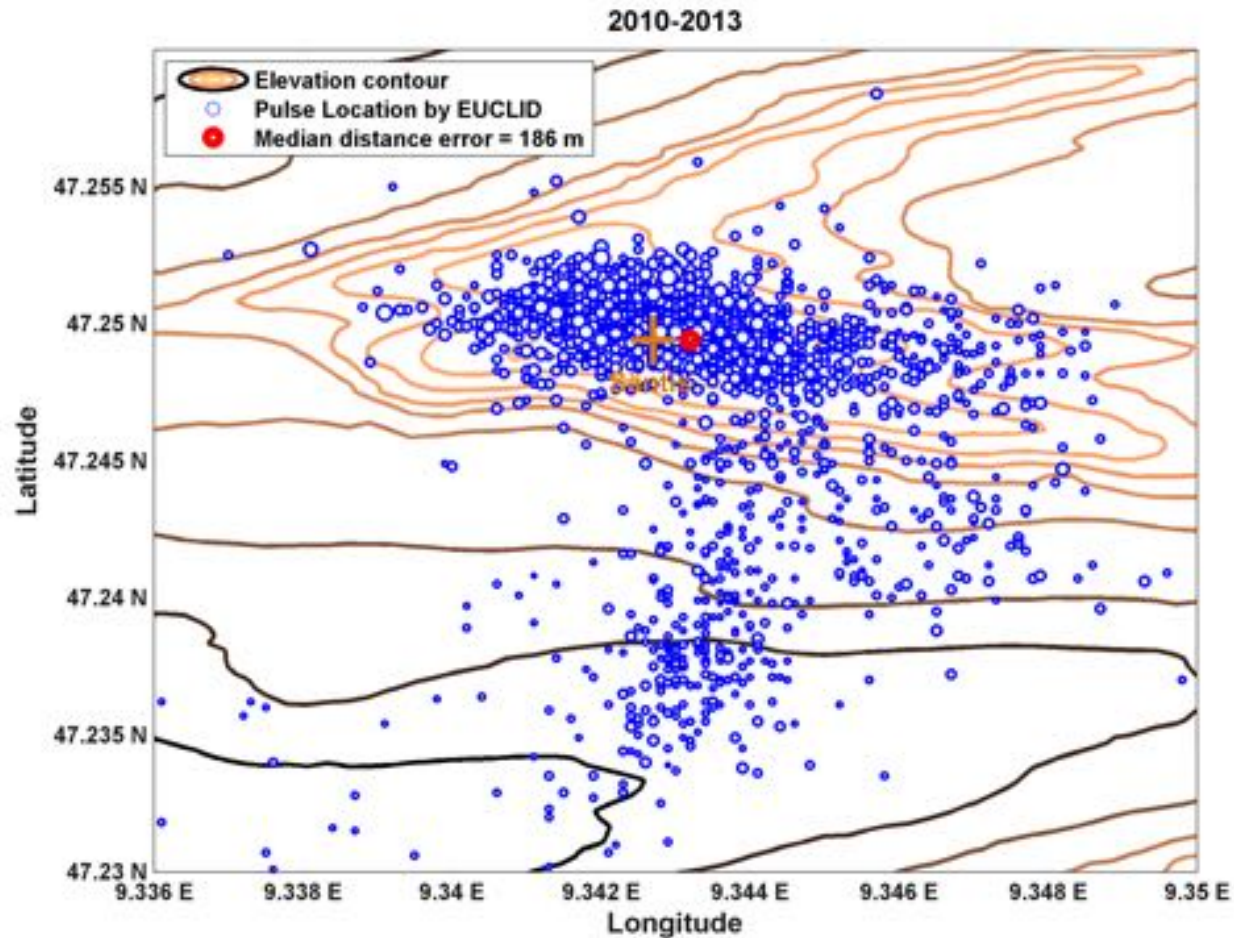
# Lightning Current Characteristics

Another example of a positive flash current

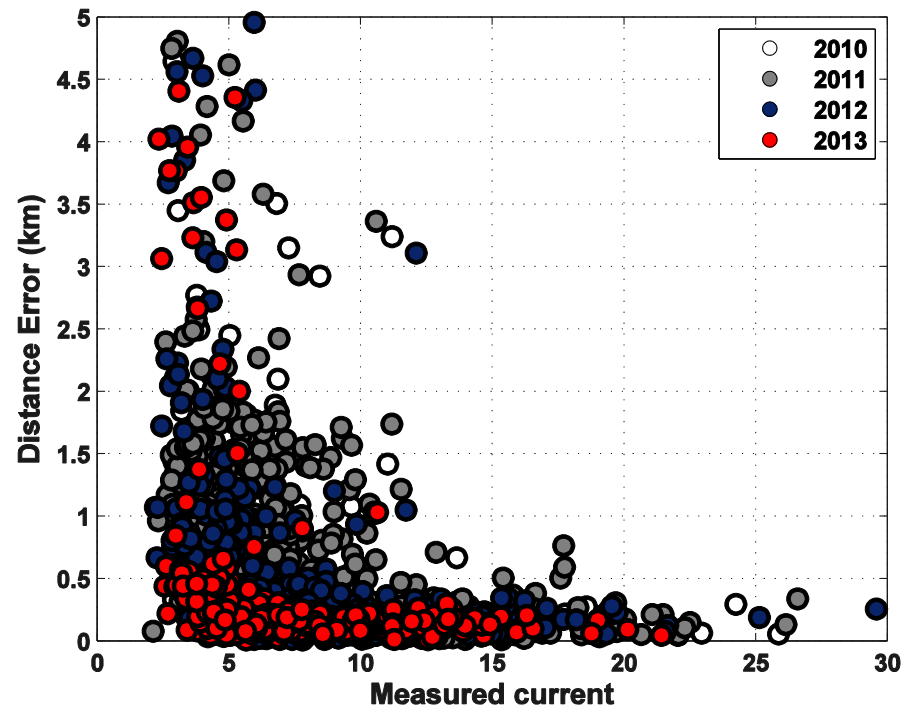




# Performance of Lightning Detection Networks



# Performance of Lightning Detection Networks



# Conclusions

- Instrumentation of the Säntis Tower for lightning current measurements
- Remote Maintenance, Monitoring, Calibration and Control System
- Long term:
  - Enlarge our measurement database
  - Revisit statistical data
  - Enhance instrumentation
  - Create a Center for Lightning Research where international groups can conduct experiments and share data

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Improve our understanding of the lightning phenomenon and its Effects



# Säntis Project Team



Dr. Carlos Romero



Mohammad Azadifar



Alex Smorgonskiy



Prof. M. Rubinstein



Prof. M. Paolone



Prof. D. Pavanello

# Säntis Project team: Collaborating Institutions

heig-vd

Haute Ecole d'Ingénierie et de Gestion  
du Canton de Vaud



ALMA MATER STUDIORUM  
UNIVERSITÀ DI BOLOGNA

**UF** UNIVERSITY of  
**FLORIDA**  
*The Foundation for The Gator Nation*



UPPSALA  
UNIVERSITET



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# Annual number of thunderstorm days on Säntis

