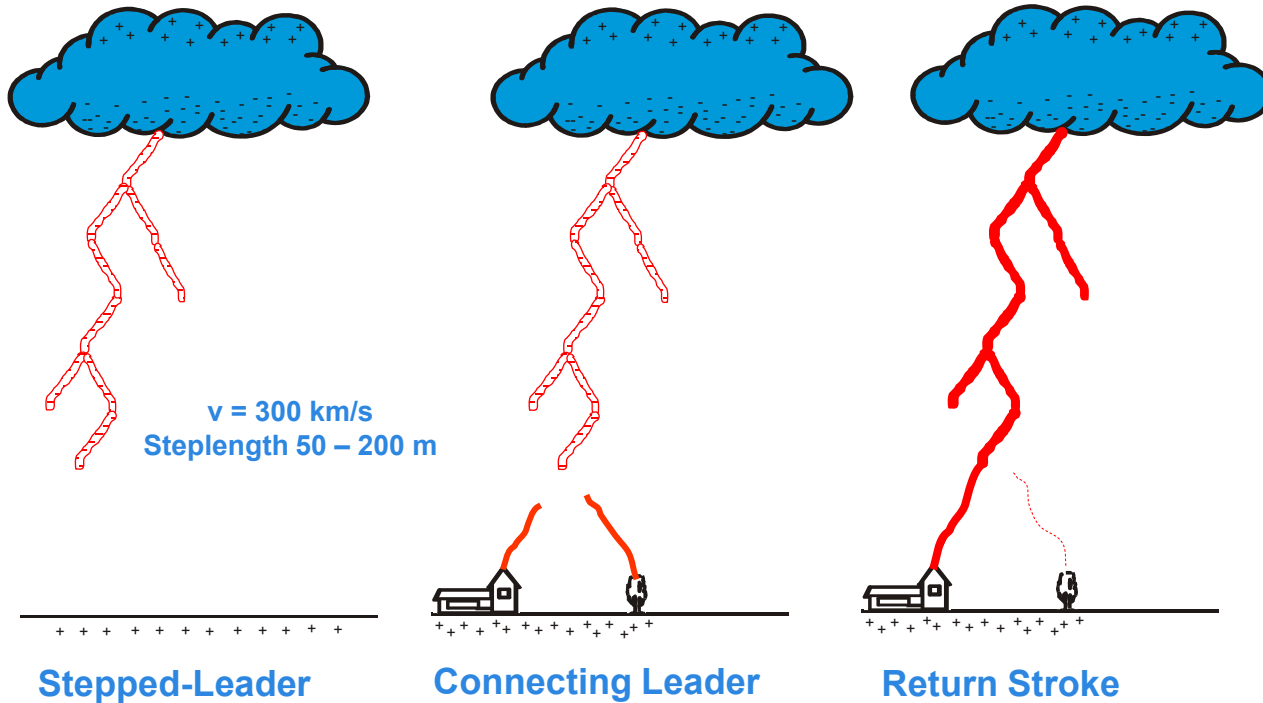
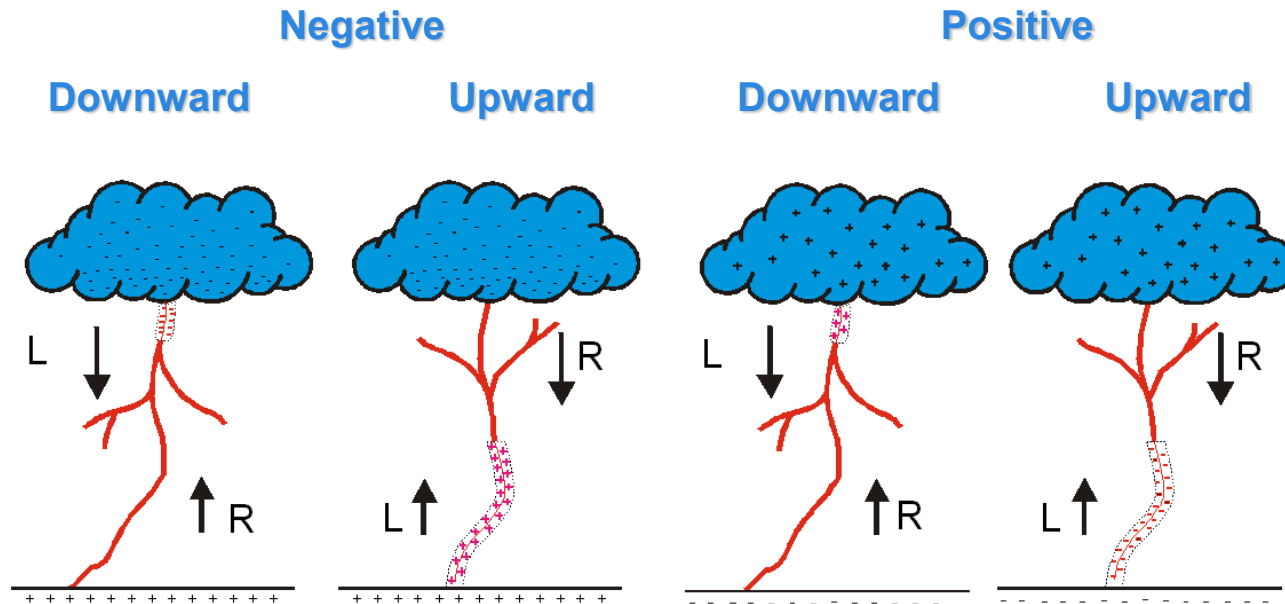


Grundlagen über Blitze und Blitzortung



Arten von WE Blitzen





Aufwärtsblitz Kitzbühler Horn



Aufwärtsblitz Dobratsch



Neg. Blitz – verschiedene Kanäle



Dieser LKW fährt!

Und am Ende des
Videos schiebt sich
der
Scheibenwischer
ins Bild

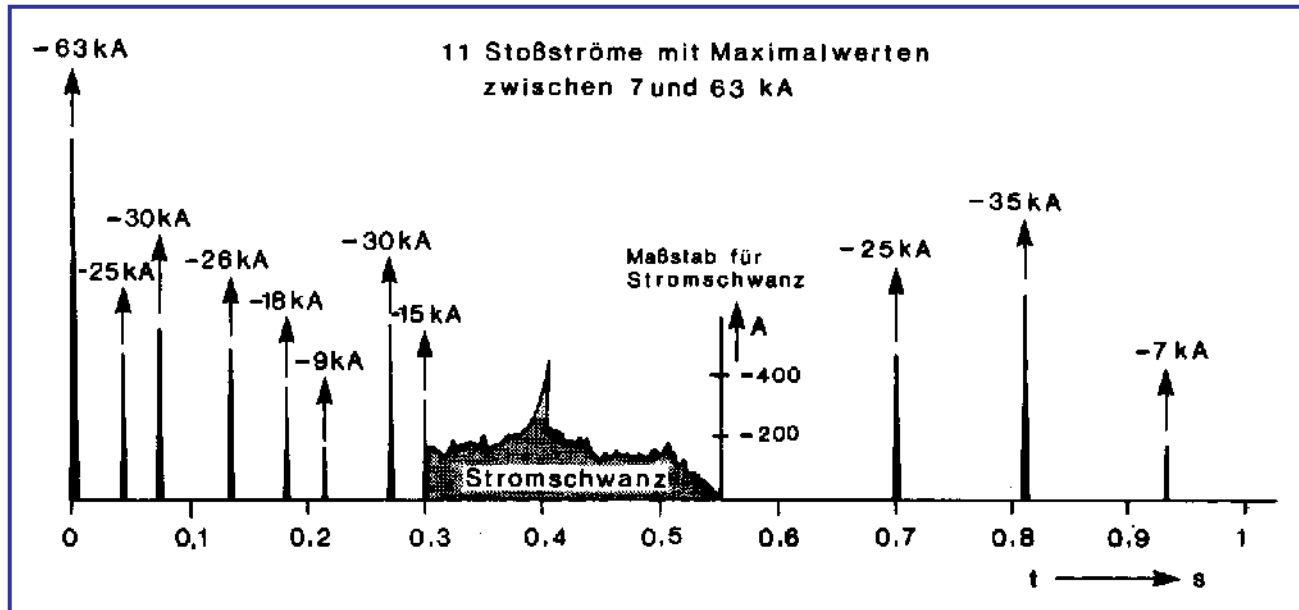
Positiver Blitz 54kA



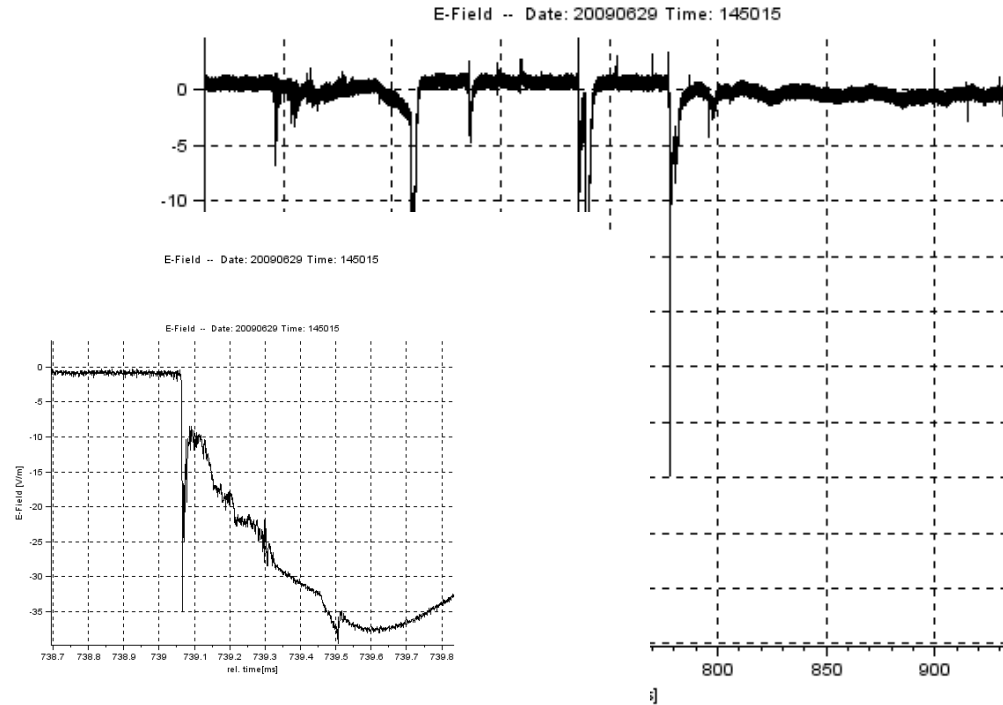
Überlagerung der Recoil Leader



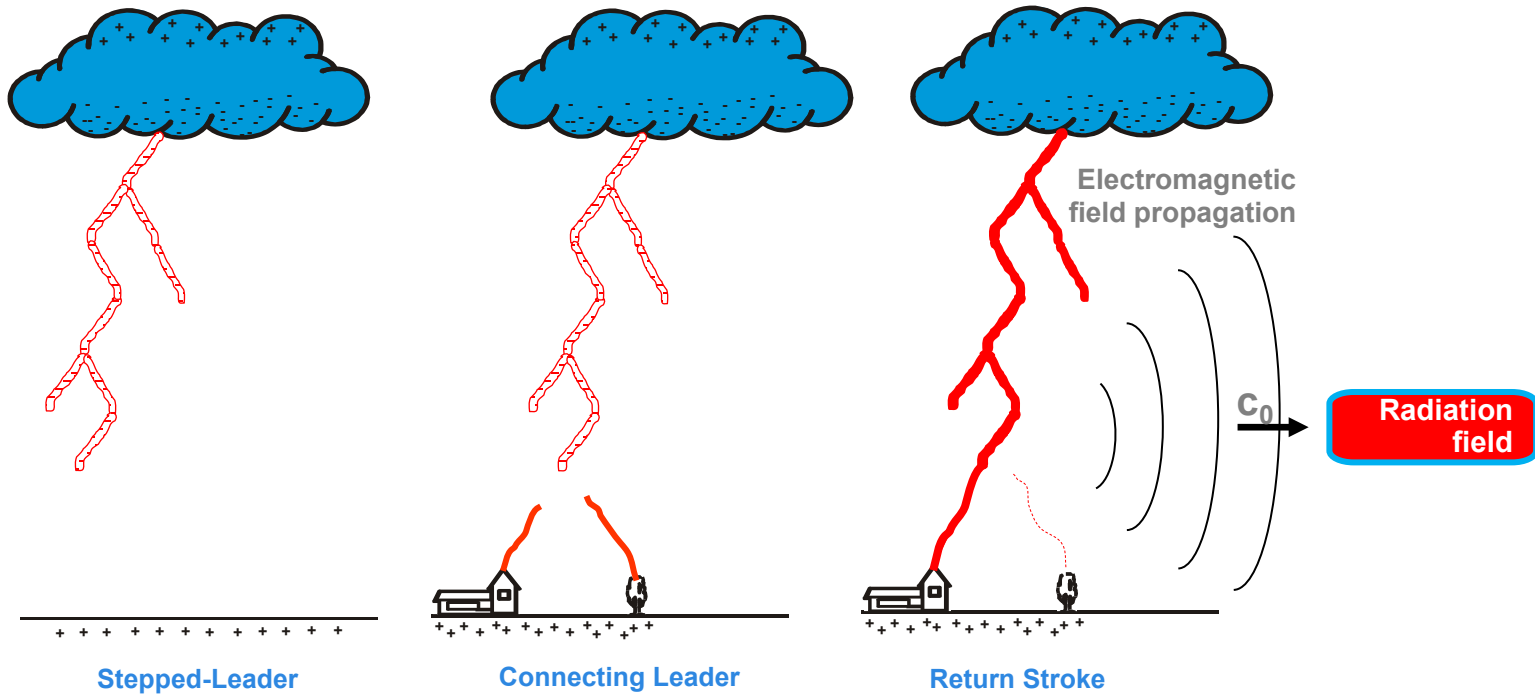
Gemessene Blitzströme (Berger)



E-Feld eines Blitzes



ALDIS/EUCLID



Elektromagnetische Feldausbreitung & Detektion

$0\mu s$

Das Feld wird verwendet zur

- Detektion
- Lokalisierung
- Amplitudenschätzung

5km

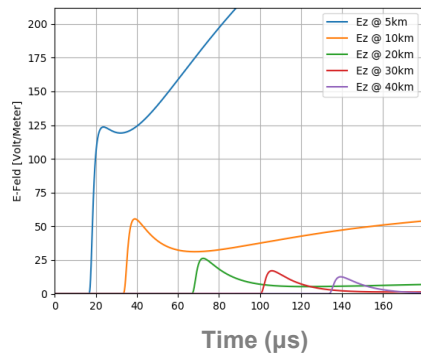
10km

20km

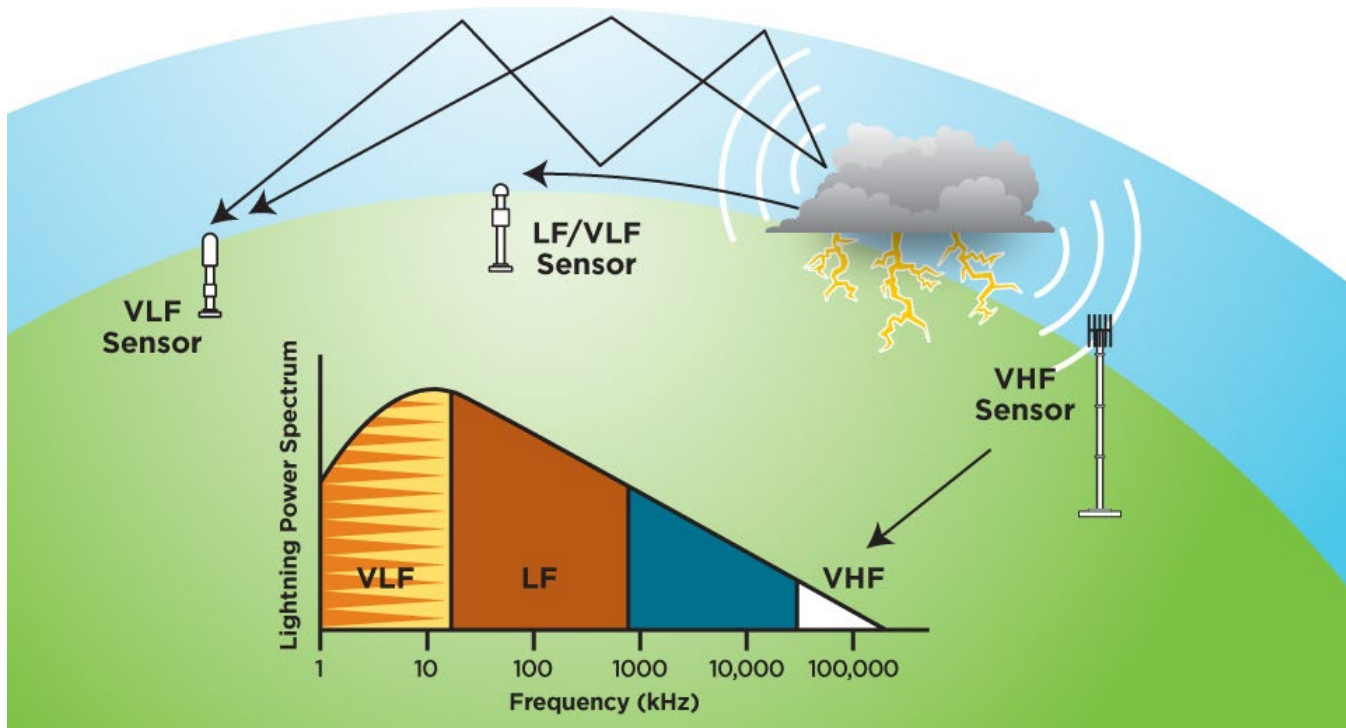
30km

40km

Detektiertes Feld



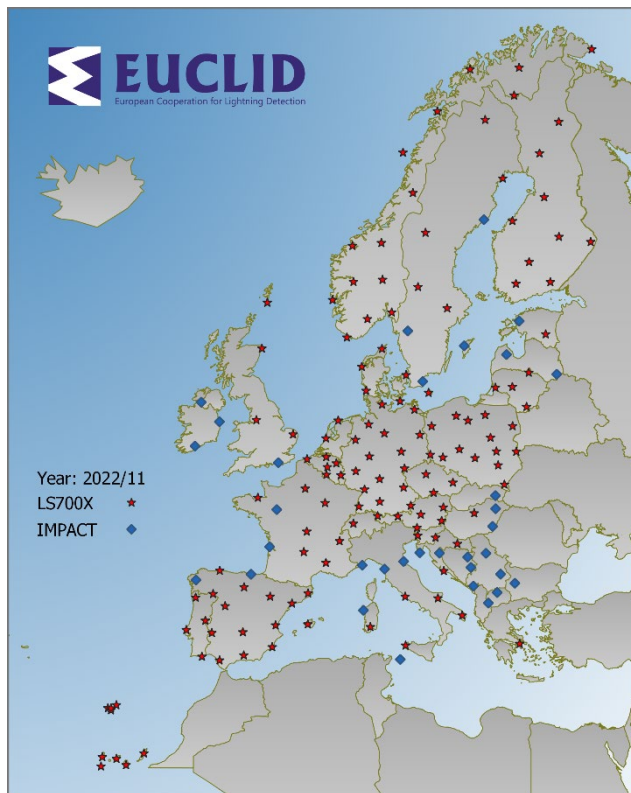
Frequenzbereiche der Blitzortung



EUCLID Netzwerk Konfiguration (11/2022)

LS700X 136
IMPACT 34

Total 170



Installierte LF Sensoren (in EUCLID)

IMPACT Sensor



LS 700X



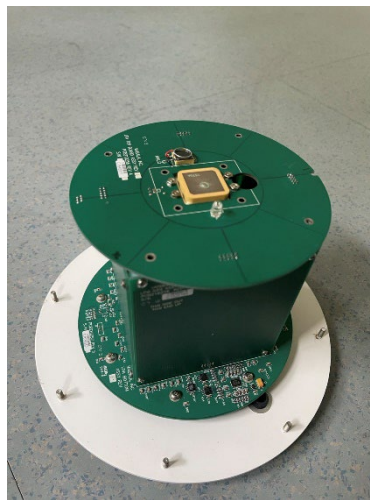
Installierte LF Sensoren (in EUCLID)



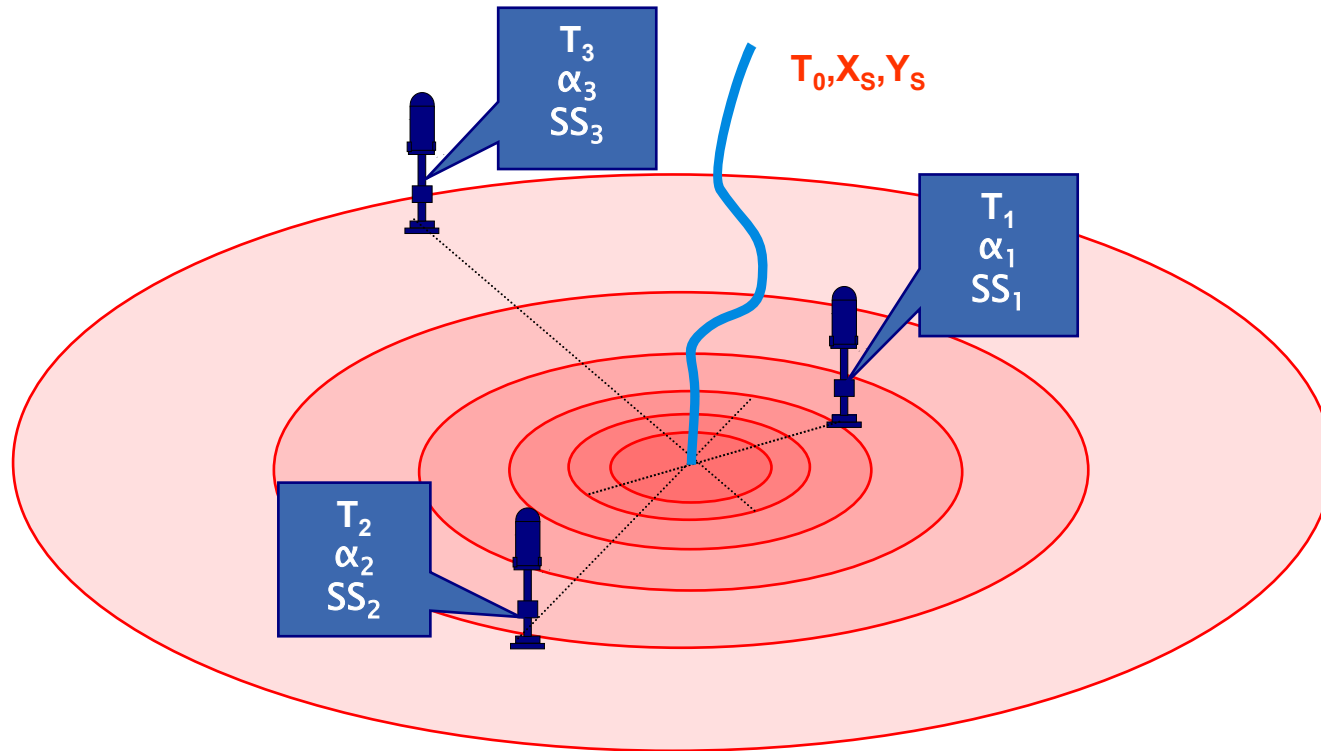
IMPACT Sensor



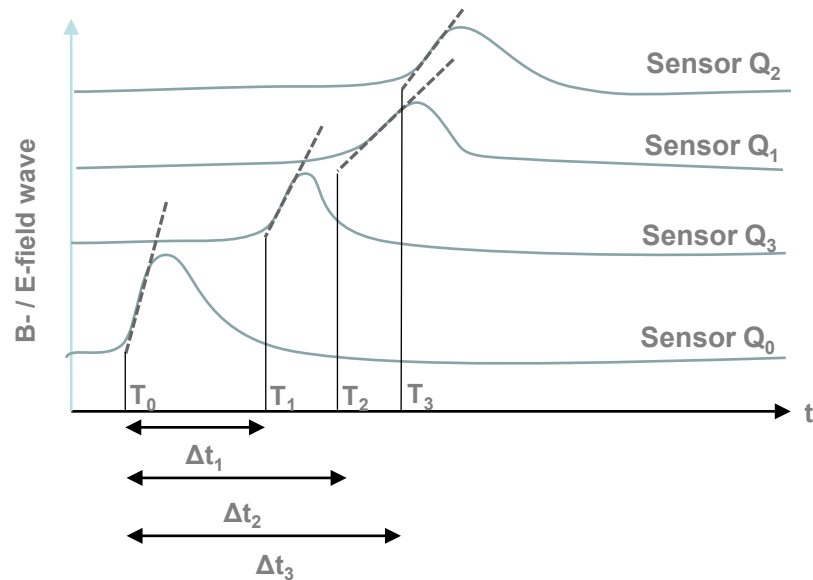
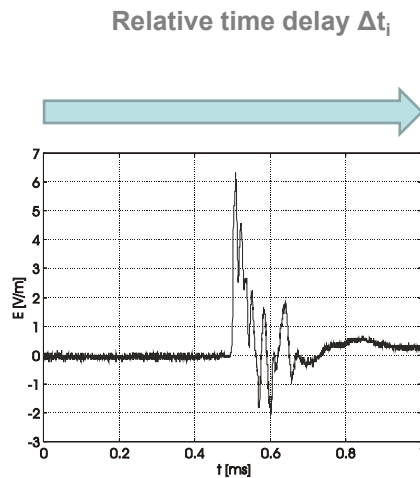
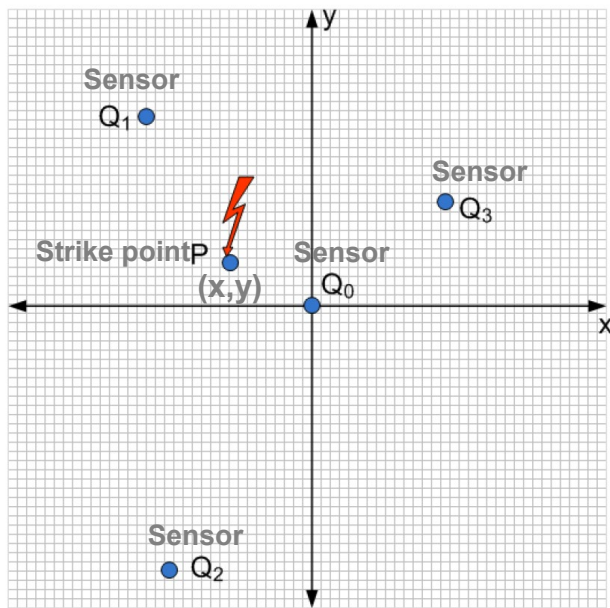
LS 700X



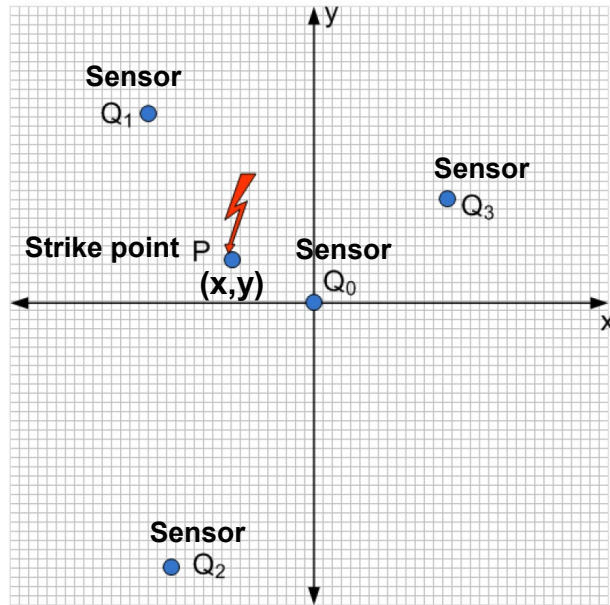
Sensor Meldungen an den TLP



Lightning strike point at $P(x,y)$ at absolute time T



Lightning strike point at $P(x_s, y_s)$ at absolute time T



Relative time delay Δt_i



Method:
Hyperbolic positioning /
multilateration

$$\overline{PQ_0} - \overline{PQ_i} = c \cdot \Delta t_i$$

$$\overline{PQ_i} = \overline{PQ_0} - c \cdot \Delta t_i$$

$$(\overline{PQ_i})^2 = (\overline{PQ_0} - c \cdot \Delta t_i)^2$$

$$(\overline{PQ_i})^2 = (\overline{PQ_0})^2 - 2 \cdot \overline{PQ_0} \cdot c \cdot \Delta t_i + c^2 \cdot \Delta t_i^2$$

$$(x - x_i)^2 + (y - y_i)^2 = x^2 + y^2 - 2 \cdot \overline{PQ_0} \cdot c \cdot \Delta t_i + c^2 \cdot \Delta t_i^2$$

Hyperbola equations:

$$2 \cdot x_1 x + 2 \cdot y_1 y - 2 \cdot \overline{PQ_0} \cdot c \cdot \Delta t_1 = x_1^2 + y_1^2 - c^2 \cdot \Delta t_1^2$$

$$2 \cdot x_2 x + 2 \cdot y_2 y - 2 \cdot \overline{PQ_0} \cdot c \cdot \Delta t_2 = x_2^2 + y_2^2 - c^2 \cdot \Delta t_2^2$$

$$2 \cdot x_3 x + 2 \cdot y_3 y - 2 \cdot \overline{PQ_0} \cdot c \cdot \Delta t_3 = x_3^2 + y_3^2 - c^2 \cdot \Delta t_3^2$$

Intersection of
hyperbolae $\rightarrow P$
(least squares
method!)

Lightning strike point at $P(x_s, y_s)$ at absolute time T

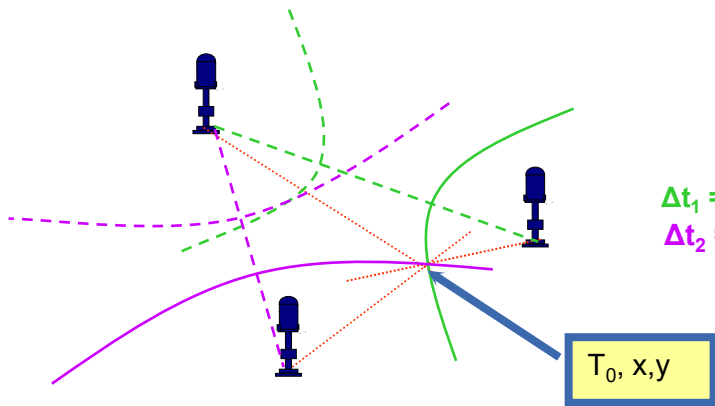


Illustration created by ALDIS

Relative time
delay Δt_i

$$\Delta t_1 = T_2 - T_1$$
$$\Delta t_2 = T_3 - T_1$$

$$\overline{PQ_0} - \overline{PQ_i} = c \cdot \Delta t_i$$

$$\overline{PQ_i} = \overline{PQ_0} - c \cdot \Delta t_i$$

$$(\overline{PQ_i})^2 = (\overline{PQ_0} - c \cdot \Delta t_i)^2$$

$$(\overline{PQ_i})^2 = (\overline{PQ_0})^2 - 2 \cdot \overline{PQ_0} \cdot c \cdot \Delta t_i + c^2 \cdot \Delta t_i^2$$

$$(x - x_i)^2 + (y - y_i)^2 = x^2 + y^2 - 2 \cdot \overline{PQ_0} \cdot c \cdot \Delta t_i + c^2 \Delta t_i^2$$

Hyperbola equations:

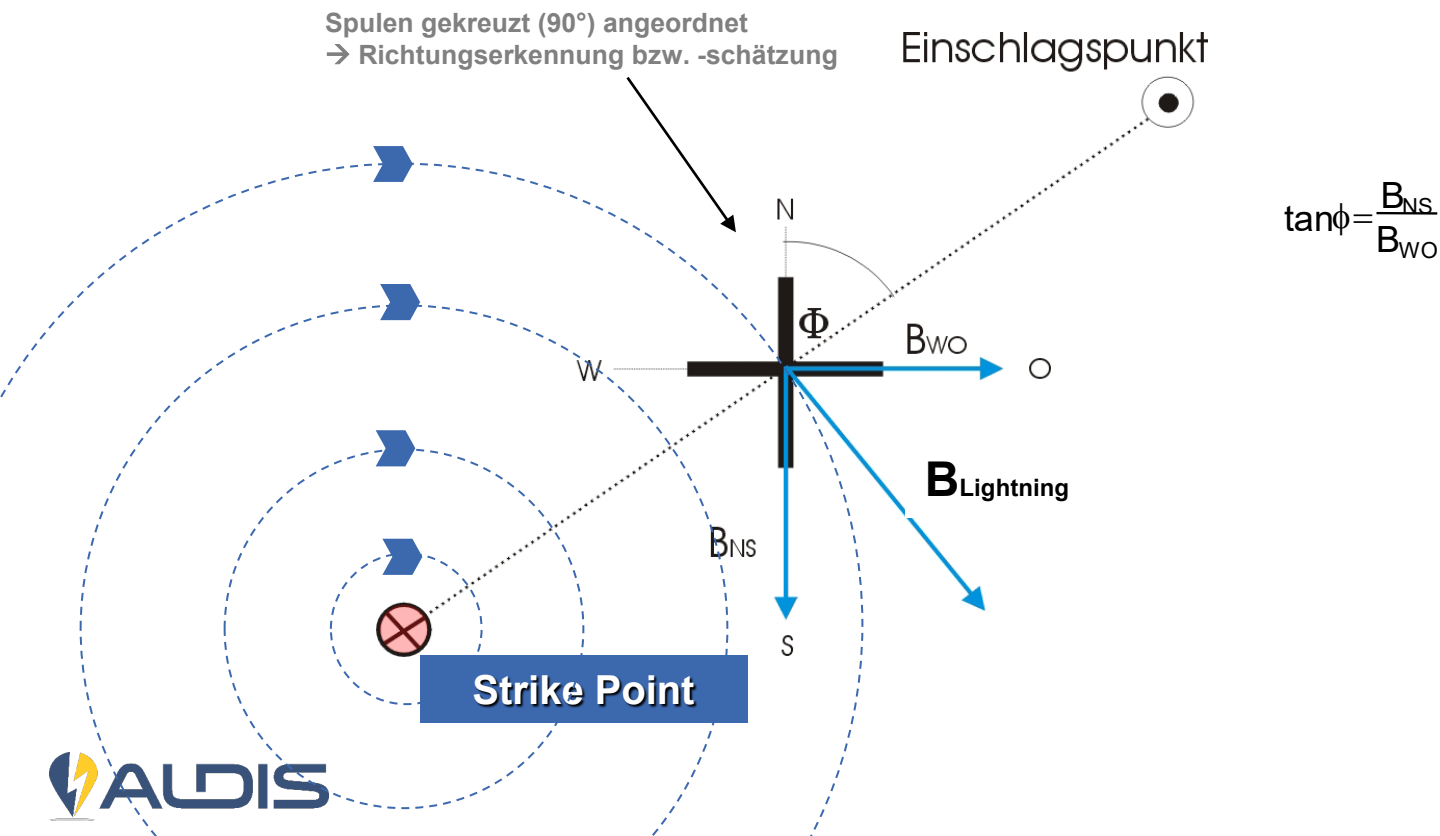
$$2 \cdot x_1 x + 2 \cdot y_1 y - 2 \cdot \overline{PQ_0} \cdot c \cdot \Delta t_1 = x_1^2 + y_1^2 - c^2 \cdot \Delta t_1^2$$

$$2 \cdot x_2 x + 2 \cdot y_2 y - 2 \cdot \overline{PQ_0} \cdot c \cdot \Delta t_2 = x_2^2 + y_2^2 - c^2 \cdot \Delta t_2^2$$

$$2 \cdot x_3 x + 2 \cdot y_3 y - 2 \cdot \overline{PQ_0} \cdot c \cdot \Delta t_3 = x_3^2 + y_3^2 - c^2 \cdot \Delta t_3^2$$

Intersection of
hyperbolae $\rightarrow$ P
(least squares
method!)

Prinzip Magnetic Direction Finding (MDF)



Lightning location: ToA & MDF combined

Lightning located at T_0, x_s, y_s

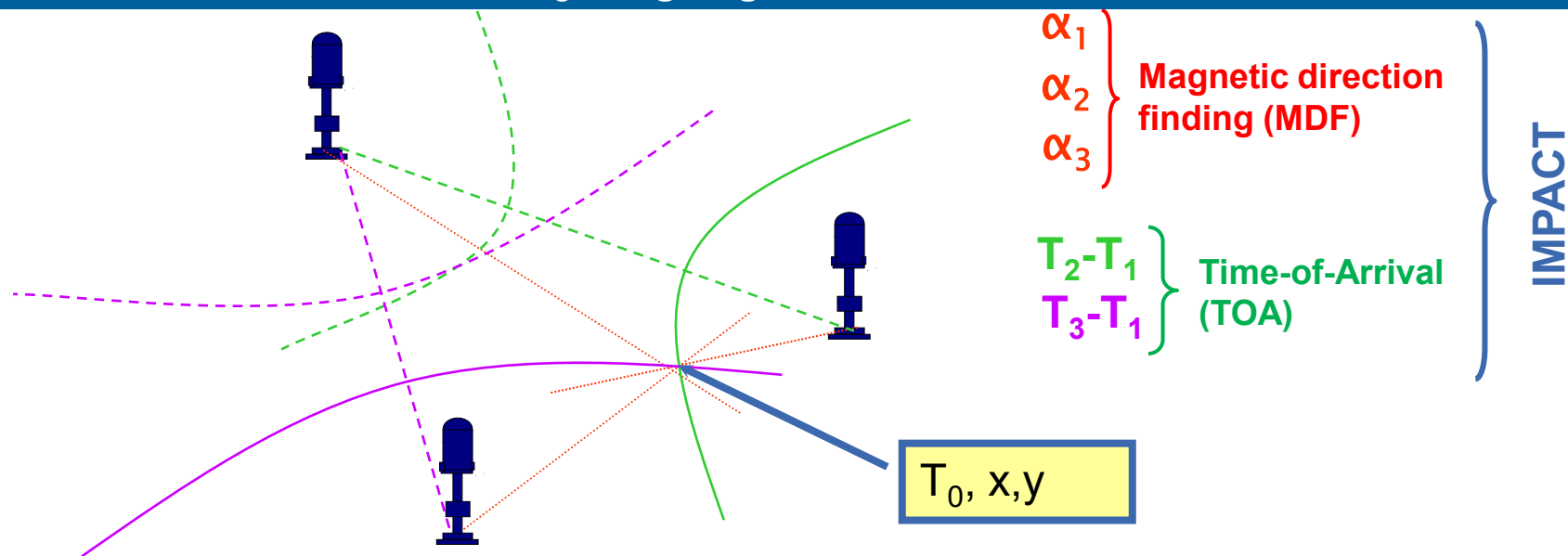
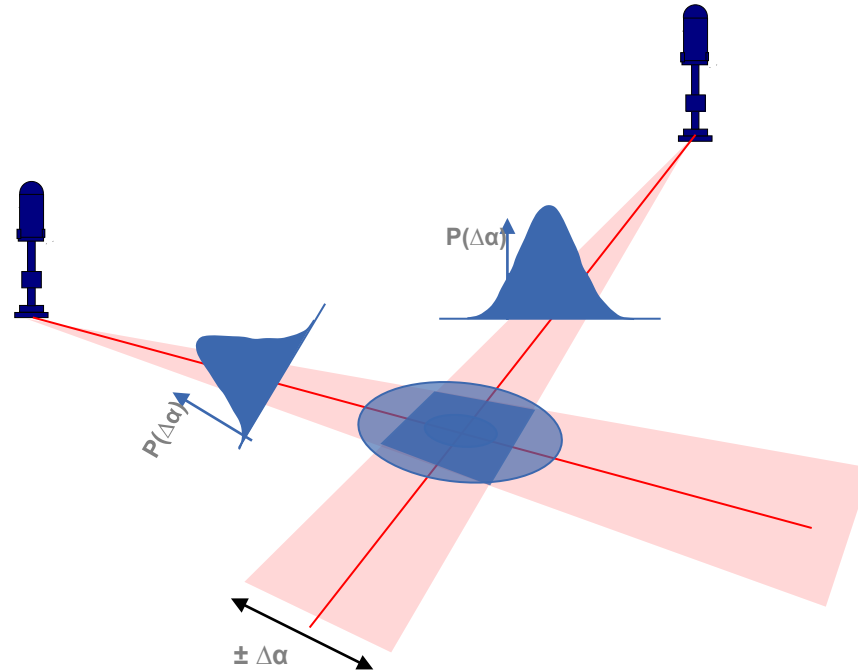


Illustration created by ALDIS

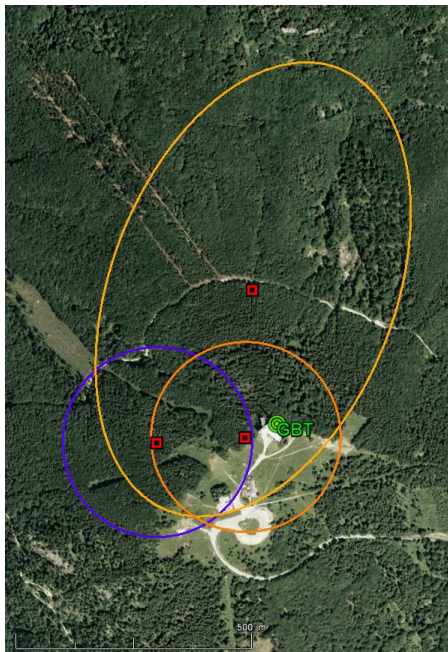
MDF min. 2 sensors necessary
TOA min. 3 sensors necessary

Confidence (Error) Ellipse

- Rauschen → führt zu Abweichungen bei der Winkelschätzung
- Annahme: Gauss'sches Rauschen mit bestimmter Wahrscheinlichkeitsdichte
- 50% Konfidenzellipse wird üblicherweise verwendet:
→ 50% Wahrscheinlichkeit, dass der Einschlagspunkt innerhalb der Ellipse liegt

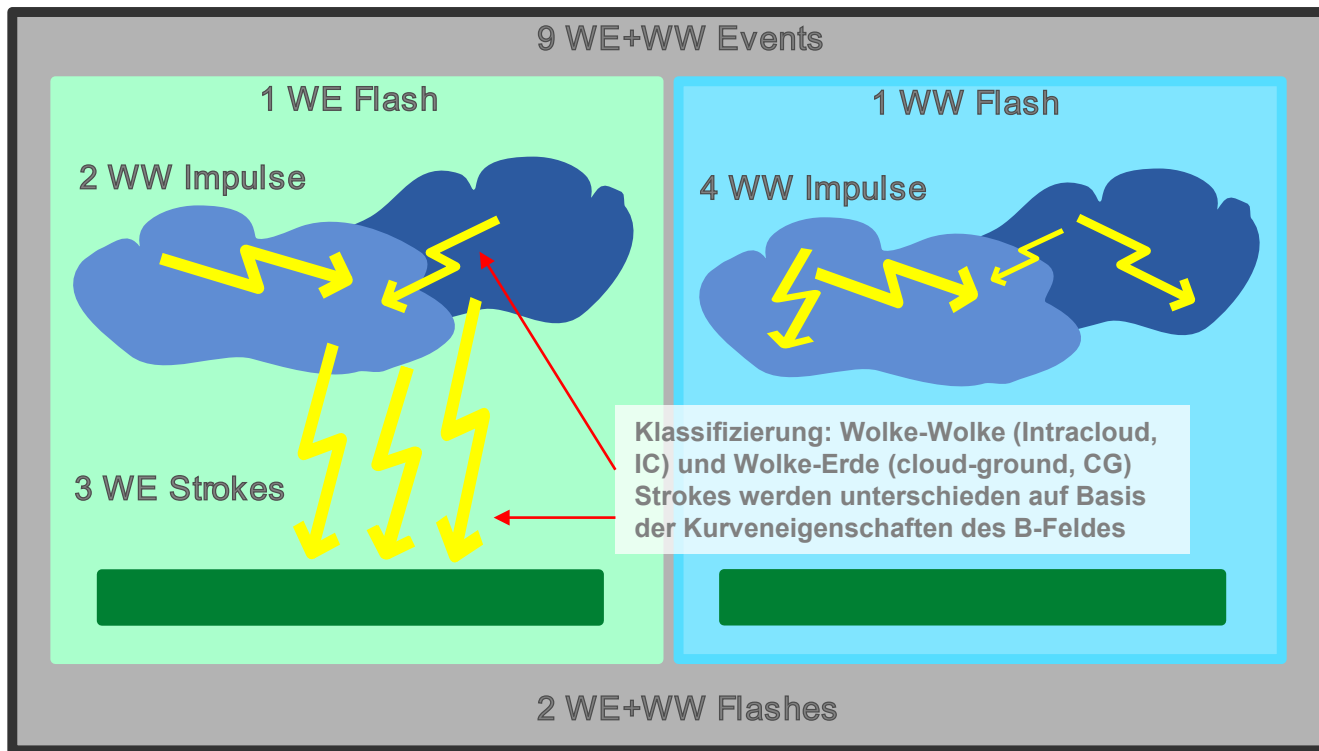


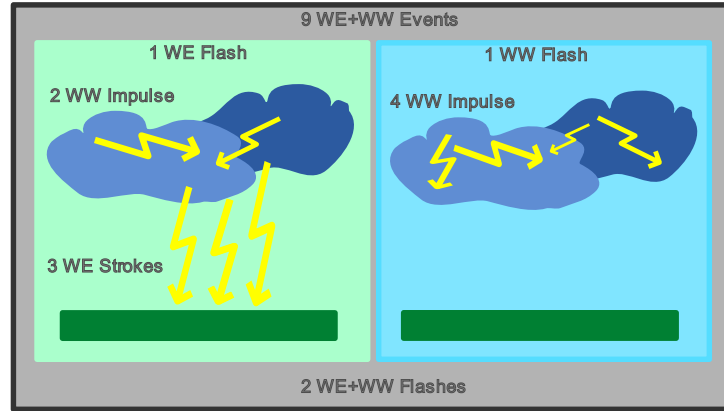
Flash mit 3 Strokes am Gaisberg Turm



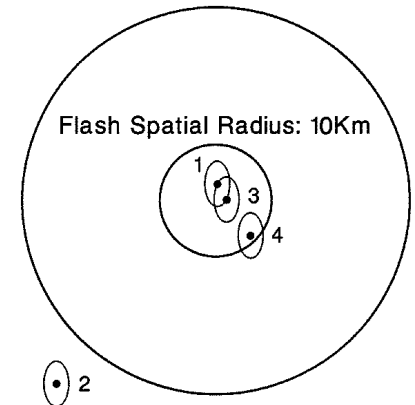
- 3 Strokes durch ALDIS geortet
- Zwei 50% Error-Ellipsen inkludieren den Turm (orange)
- Eine 50% Ellipse umschließt den Turm NICHT, ist aber sehr nah dran (blau)

Stroke/Event to Flash Grouping



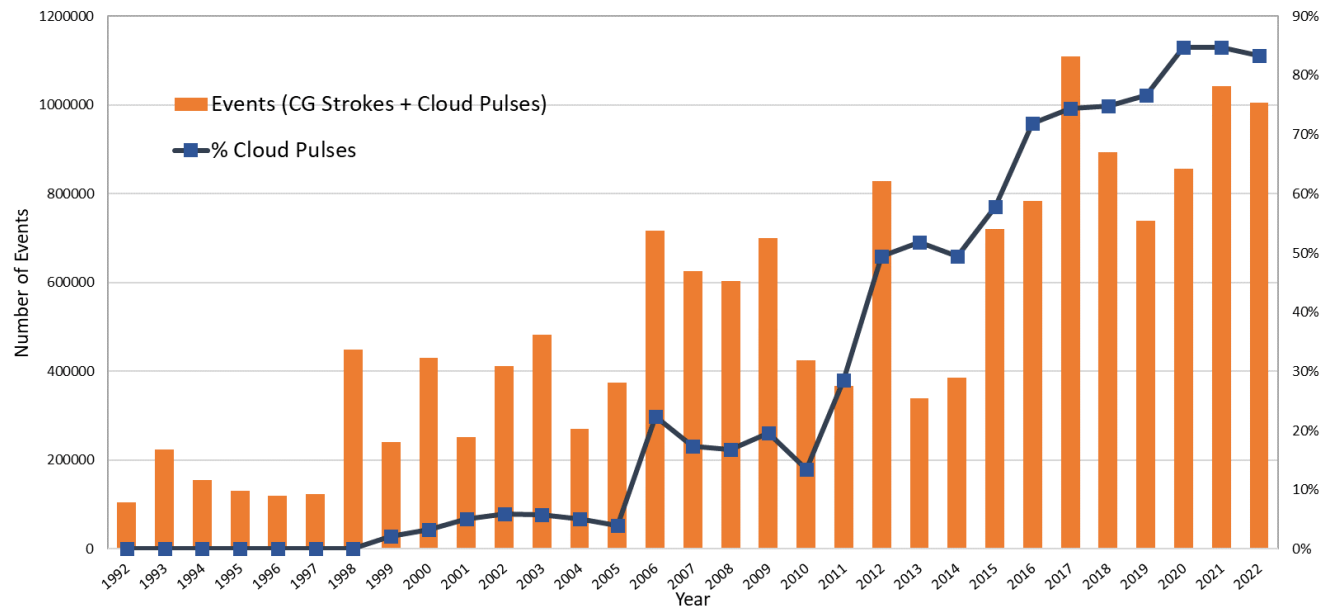


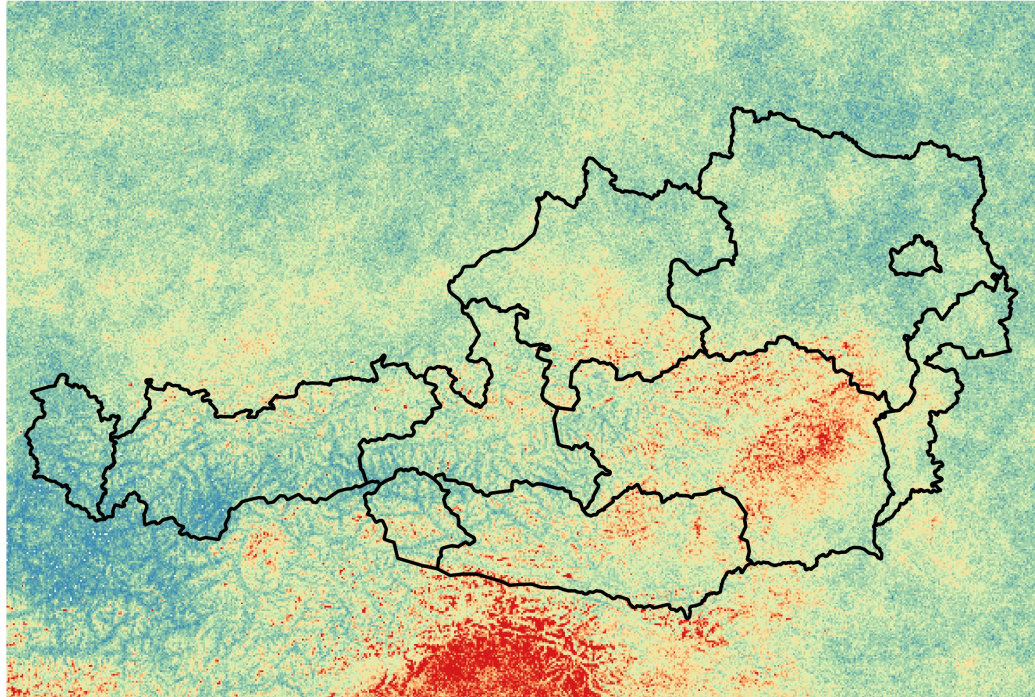
- LLS lokalisiert individuelle Teilentladungen
- Strokes werden zu Flashes gruppiert auf Basis von zeitlich-örtlichen Kriterien:
 - Distanz (< 10 km zueinander)
 - Zeit (< 500 ms)



Events in Österreich (innerhalb der Bundesgrenzen)

1994 IMPACT
1998 SLO and DE connected
2006 LS7000
2011 LS7001 Sensor Software 1.6.0
2011 Sensor based OSTC
2012 Prop Corr
2015 LS7002+Iflocated
2016 CC
2020 CC2
2022 CC3





Legende

WE Blitzdichte (10 Jahre)

- 0 km-2 Jahr-1
- 1 km-2 Jahr-1
- 2 km-2 Jahr-1
- 3 km-2 Jahr-1
- 4 km-2 Jahr-1
- 5 km-2 Jahr-1

- Detection Efficiency
 - Flash DE
 - Stroke DE
- Ortungsgenauigkeit
- Klassifizierung von WE und WW
Blitzen
- Blitzstrombestimmung
- Anzahl an Outliern

- ALDIS/EUCLID – validiert mit “Ground truth data”
- Negative Blitze:
 - Flash DE ~ 98 %
 - Stroke DE ~ 83% - 95 %
 - Median Ortungsgenauigkeit < 150m (konservative Schätzung)
- Positive Blitze:
 - Flash DE ~ 97 %
 - Stroke DE ~ 92 %

Gaisberg Messungen

Projekt Gaisberg

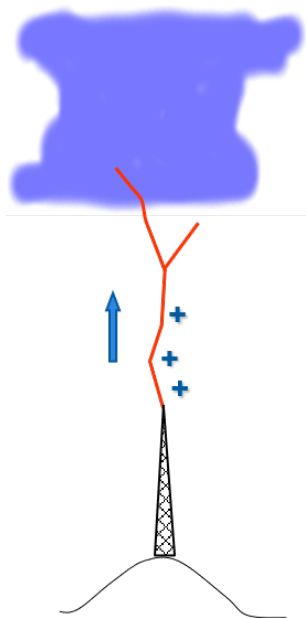
Heuer (2023):
25 Jahre Gaisberg
Blitzstrommessung!



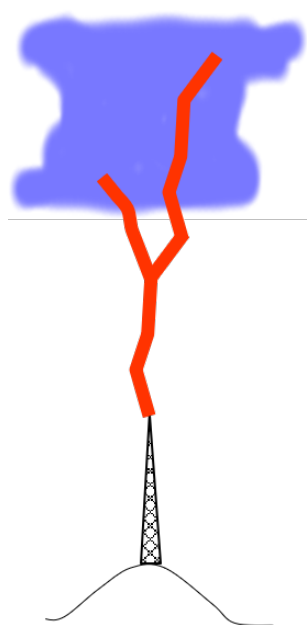
Turm - Messaufbau



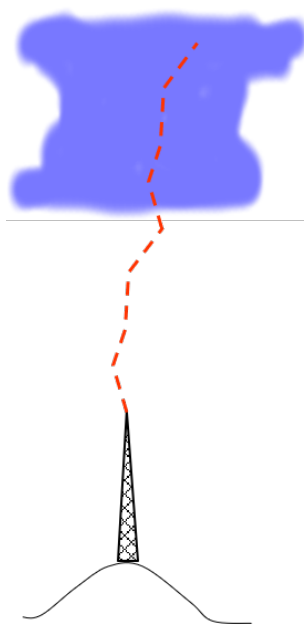
Turm – getriggerte Blitze



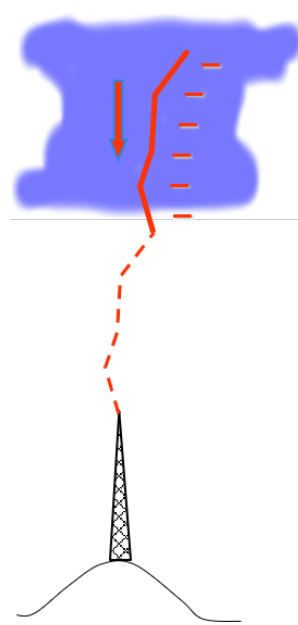
**Upward
pos. leader**



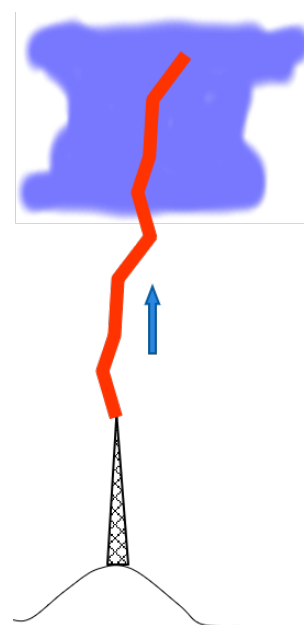
**Initial continuous
current (ICC)**



**No-current
interval**

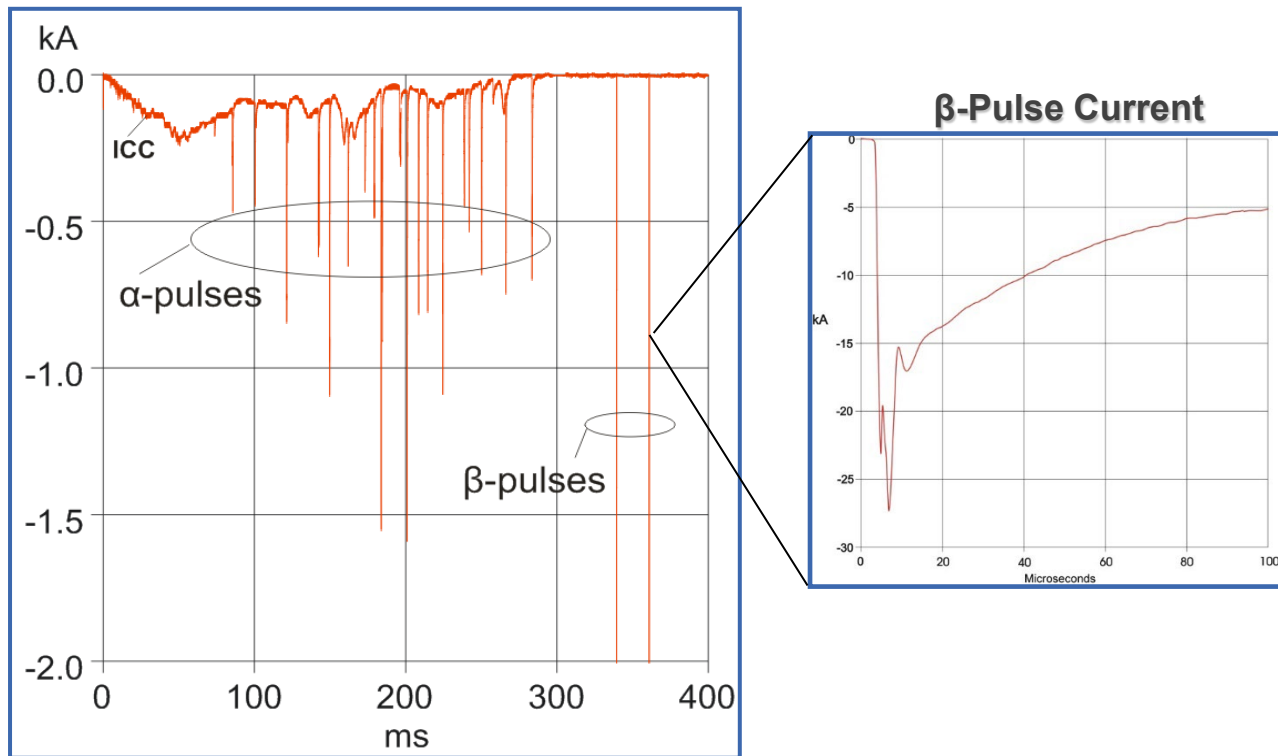


**Downward
neg. leader**

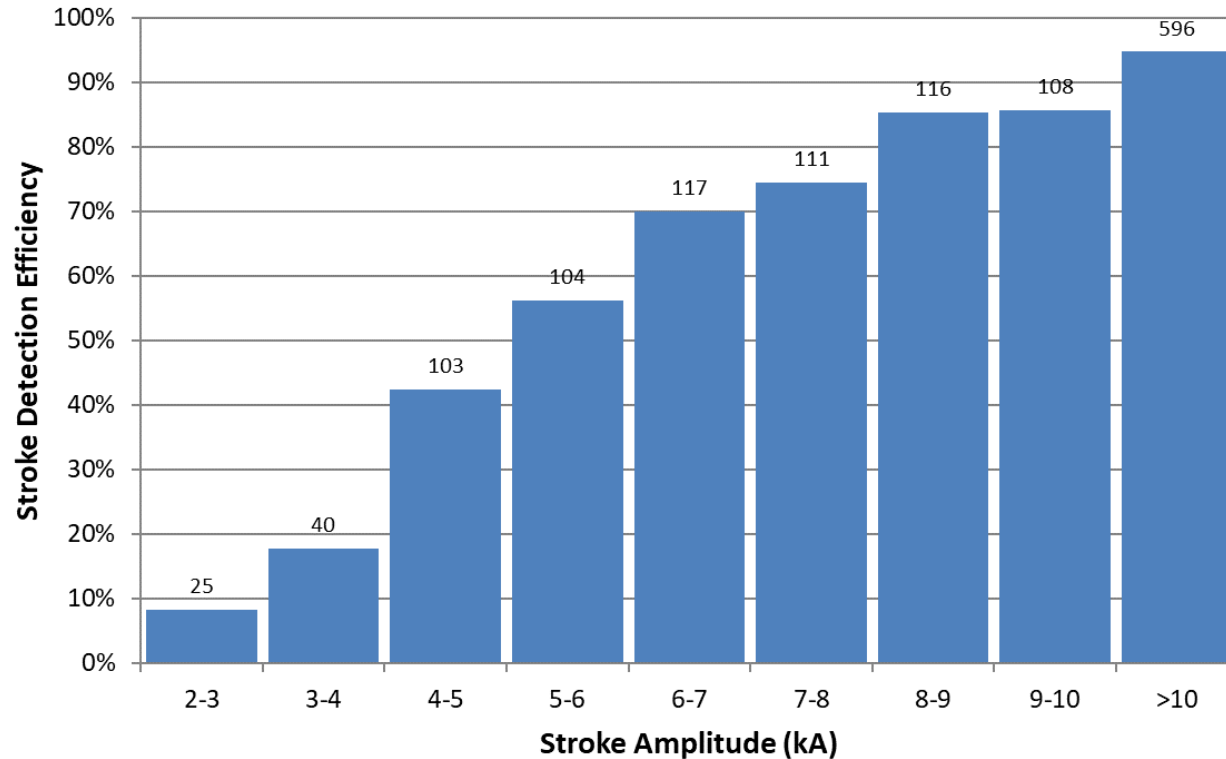


**Upward
return stroke**

Initial Continuing Current (ICC) mit α -Pulsen gefolgt von β -Pulsen

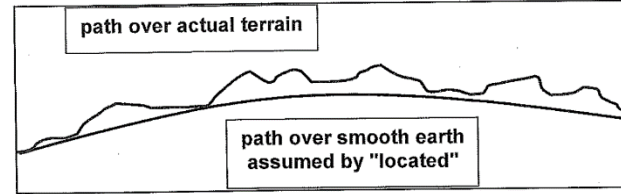
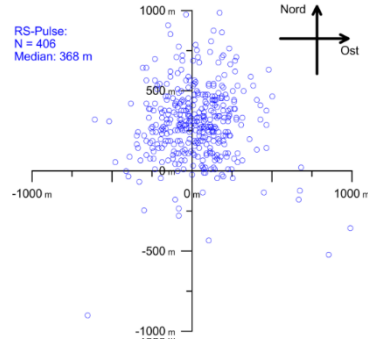


Stroke DE Gaisberg (2000 – 2022)

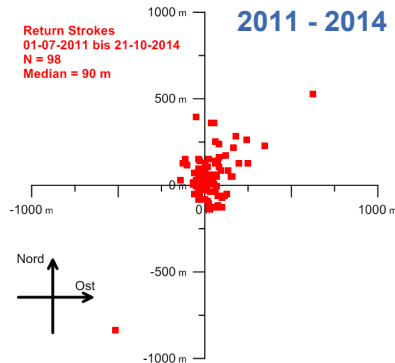


Überprüfung der Ortungsgenauigkeit → gemessene Einschläge am Gaisberg Turm als Referenz

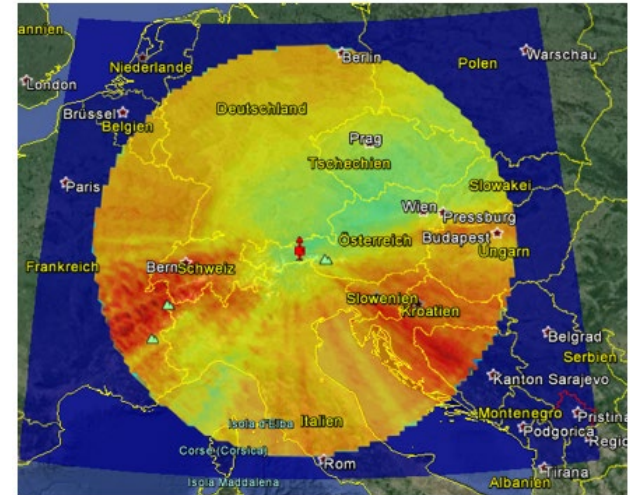
2000 - 2005



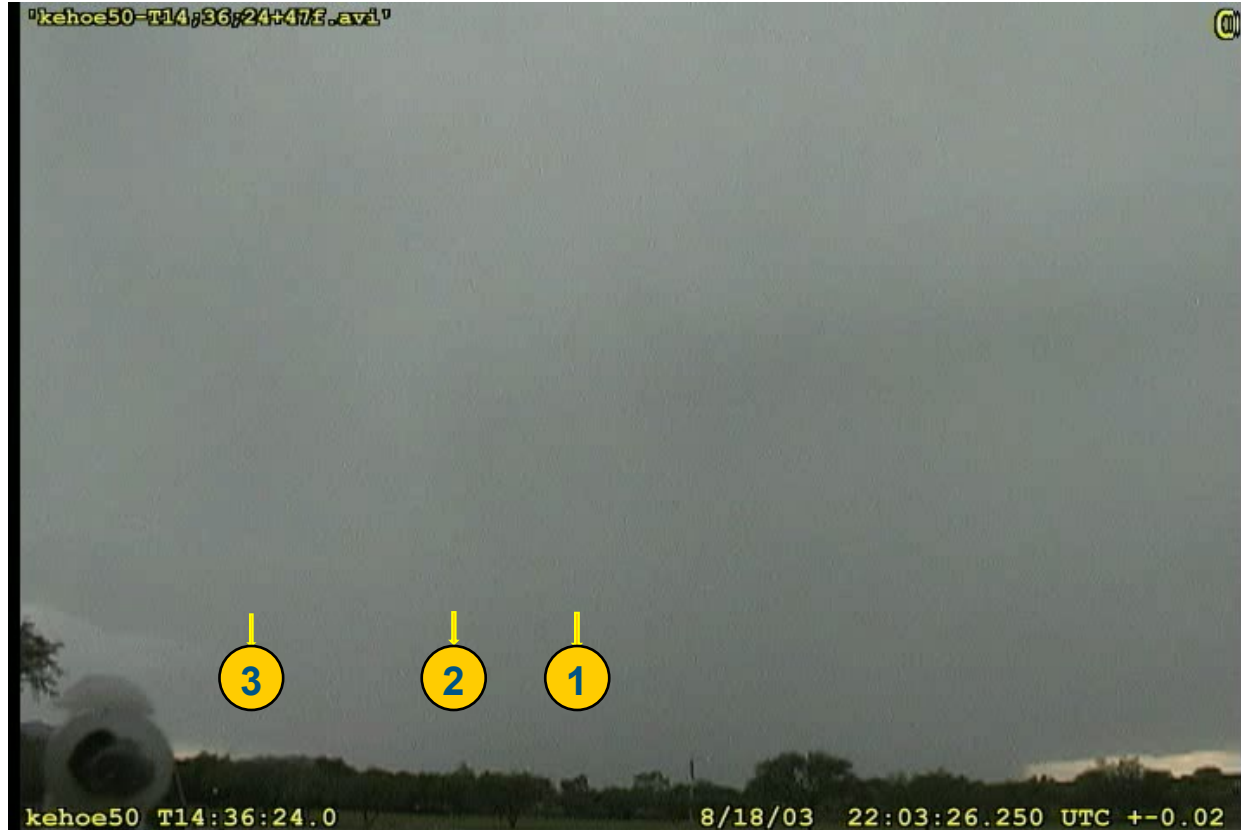
2011 - 2014



- Corrections of the propagation time, individual for each sensor (function of range and azimuth)
- Corrections are typically in the range of 0 to +10 μ s

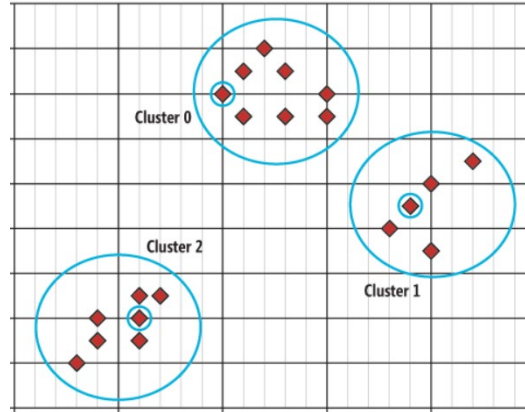


Unterschiedliche Einschlagspunkte in gleichem Wolke-Erde Flash: Ground Strike Points (GSPs)



Ground strike point clustering

In ALDIS/EUCLID data, a k-Means algorithm identifies ground strike points (GSPs)



Location accuracy (LA) determines/limits capability of GSP clustering
→ weak LA leads to bad spatial resolution and worse GSP identification

9 Stroke Flash after cluster analysis

num	date	nano	LON	LAT	amp	icloud	nbloc	numloc	numgsp	nbgsp	nblocgsp	ngc
15814398	2016-06-04 13:27:31+00	85869568	13,8061	47,6534	-5,91	f	9	1	1	3	3	t
15814398	2016-06-04 13:27:31+00	160718848	13,9225	47,6514	-4,63	f	9	2	➡ 1	3	3	➡ f
15814398	2016-06-04 13:27:31+00	200720640	13,8723	47,6700	-9,37	f	9	3	2	3	1	t
15814398	2016-06-04 13:27:31+00	226299904	13,8425	47,6524	-8,77	f	9	4	➡ 1	3	3	➡ f
15814398	2016-06-04 13:27:31+00	623446016	13,7603	47,6378	-11,04	f	9	5	3	3	5	t
15814398	2016-06-04 13:27:31+00	647960576	13,7585	47,6370	-4,51	f	9	6	3	3	5	f
15814398	2016-06-04 13:27:31+00	706191872	13,7594	47,6370	-6,14	f	9	7	3	3	5	f
15814398	2016-06-04 13:27:31+00	747384832	13,7584	47,6373	-6,44	f	9	8	3	3	5	f
15814398	2016-06-04 13:27:31+00	825475328	13,7838	47,6551	-2,33	f	9	9	3	3	5	f

nbloc

Nr. of located strokes

numloc

Stroke Index (1, 2, nbloc)

numgsp

Stroke assignment to computed GSPs (1,2,3)

nbgsp

Number of GSPs (nb clusters, nbgsp=3 in the above example)

nblocgsp

Total return strokes in the given GSP

ngc

New ground contact (t .. true, f .. false)



Danke für Ihre Aufmerksamkeit!