

# **A Preliminary Analysis of Bipolar Lightning Observed to the Gaisberg Tower from 2000 to 2008**

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# Outline

- Introduction
- Bipolar Lightning Occurrence Characteristics
- Bipolar Lightning Types Classification
- Discussion and Conclusions

# Introduction

- Bipolar lightning is defined as the lightning current waveform measured at the channel-base exhibiting a polarity reversal within the same flash. (McEachron 1939, 1941 first reported from his measurements at the Empire State Building)
- To date the knowledge of the physics of bipolar lightning is limited . (Rakov and Uman, Rakov, 2003)
- Measurements of lightning currents on tall towers provide a useful way to investigate the occurrence of bipolar flashes and its physical mechanism.

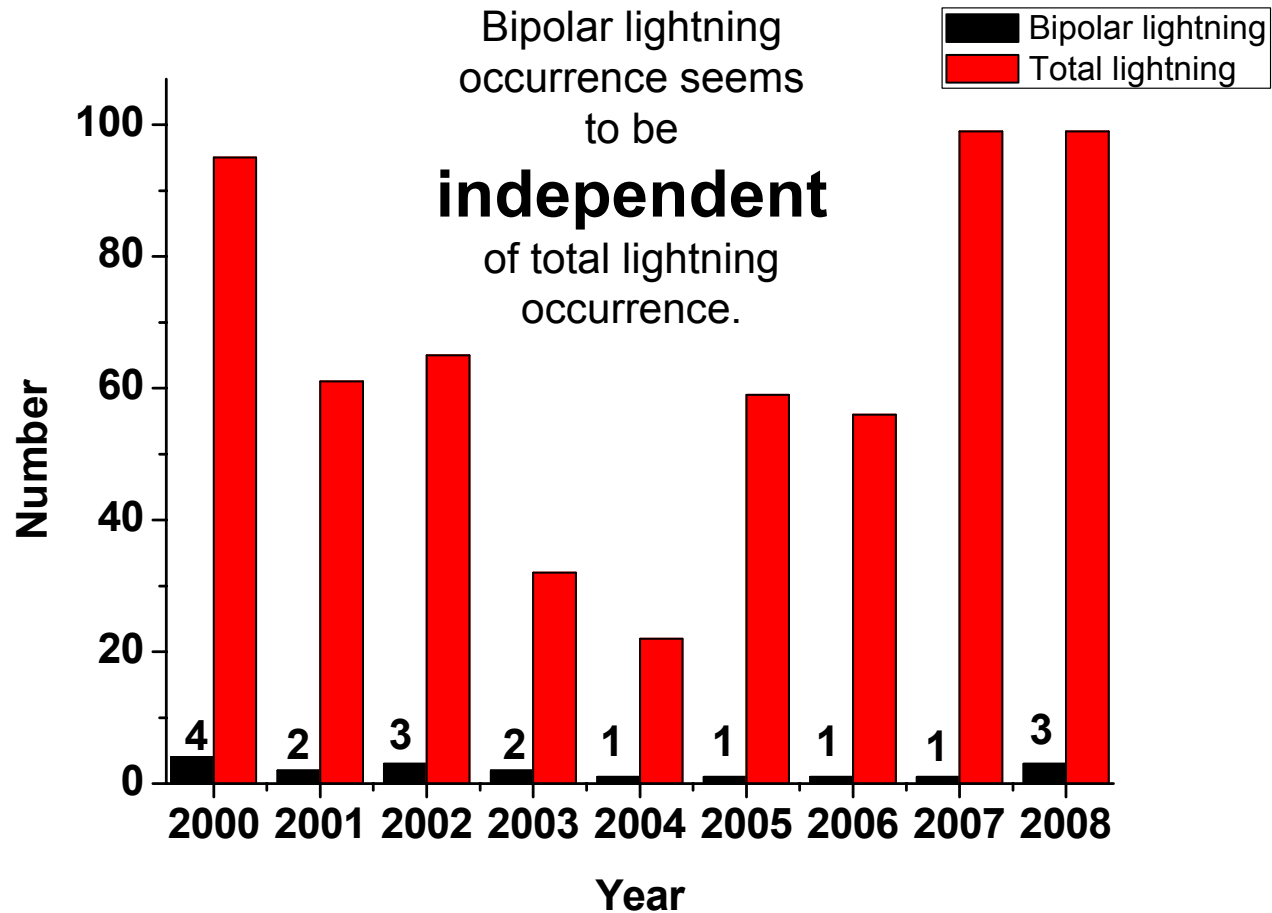
# Introduction

- Recently, some bipolar lightning research works are involved. (Krider et al. ICAE 2007; Wang and Takagi URSI 2008; Lu and Wang et al. GRL 2009)
- In this presentation, flash current measurements with two channels (2 kA, 40 kA range) data from the Gaisberg tower from 2000 to 2008 were used for a preliminary analysis.

# Outline

- Introduction
- Bipolar Lightning Occurrence Characteristics
  - 1) Occurrence
  - 2) Charge Transfer and its Duration
- Bipolar Lightning Types Classification
- Discussion and Conclusions

# Bipolar Lightning Occurrence Characteristics



# Bipolar Lightning Occurrence Characteristics

- Bipolar lightning(2000-2008) : 18/588 ~ **3%**
- Less than 14% from Hagenguth and Anderson (1952), 6% from Berger (1978), 6.7% from Gorin and Shkilev (1984), 5-33% from Japan.
- Median value for total charge transfer of bipolar lightning from 2000-2007 is **88.9 C**, two times larger than negative upward lightning with its value **37.1 C** (Diendorfer et al. 2008).

<b>ID</b>	<b>Date</b>	<b>Qtotal (C)</b>	<b>Qnegative (C)</b>	<b>Qpositive (C)</b>	<b>Ttotal (ms)</b>	<b>Tnegative (ms)</b>	<b>Tpositive (ms)</b>
<b>95</b>	<b>2000-1-18</b>	<b>134.08</b>	<b>132.91</b>	<b>1.17</b>	<b>487.768</b>	<b>480.625</b>	<b>7.143</b>
<b>180</b>	<b>2000-8-6</b>	<b>83.24</b>	<b>79.89</b>	<b>3.35</b>	<b>586.26</b>	<b>537.908</b>	<b>8.76</b>
<b>192</b>	<b>2000-8-30</b>	<b>18.62</b>	<b>18.18</b>	<b>0.44</b>	<b>275.827</b>	<b>100.763</b>	<b>5.111</b>
<b>209</b>	<b>2000-11-8</b>	<b>61.75</b>	<b>4.53</b>	<b>57.22</b>	<b>55.662</b>	<b>21.757</b>	<b>33.863</b>
<b>246</b>	<b>2001-8-17</b>	<b>88.93</b>	<b>83.01</b>	<b>5.92</b>	<b>800</b>	<b>789.925</b>	<b>10.175</b>
<b>255</b>	<b>2001-11-8</b>	<b>260</b>	<b>57.15</b>	<b>202.85</b>	<b>301.831</b>	<b>250.009</b>	<b>51.822</b>
<b>306</b>	<b>2002-6-7</b>	<b>247.44</b>	<b>181.41</b>	<b>66.03</b>	<b>706.361</b>	<b>609.669</b>	<b>96.692</b>
<b>312</b>	<b>2002-7-6</b>	<b>149.39</b>	<b>38.52</b>	<b>110.87</b>	<b>564.85</b>	<b>376.59</b>	<b>188.26</b>
<b>316</b>	<b>2002-7-6</b>	<b>75.87</b>	<b>45.28</b>	<b>30.59</b>	<b>266.667</b>	<b>151.383</b>	<b>115.284</b>

ID	Date	Qtotal (C)	Qnegative (C)	Qpositive (C)	Ttotal (ms)	Tnegative (ms)	Tpositive (ms)
350	2003-5-31	161.24	4.4	156.84	747.074	105.746	276.845
366	2003-12-15	27.79	21.34	6.45	242.213	206.706	35.507
392	2004-11-19	147.53	147.22	0.31	657.933	655.318	2.615
402	2005-1-21	44.43	8.59	35.84	296.308	237.15	22.517
504	2006-11-3	56.7	15.14	41.56	213.74	140.798	72.942
520	2007-2-9	304.88	56.93	247.95	732.285	508.906	223.919
652	2008-3-25	154.62	3.49	151.13	173.336	50.414	55.23
653	2008-3-25	96.03	2.84	93.19	204.1	3.206	120.365
665	2008-3-25	149.91	38.81	111.1	512.352	209.123	303.229
Mean Value		125.692	52.202	73.489	434.698	301.999	90.571
Median Value		115.055	38.665	49.39	500.06	223.1365	53.526

Asymmetrical charge transfer of negative and positive currents.

The Charge Transfer is opposite to its time duration.

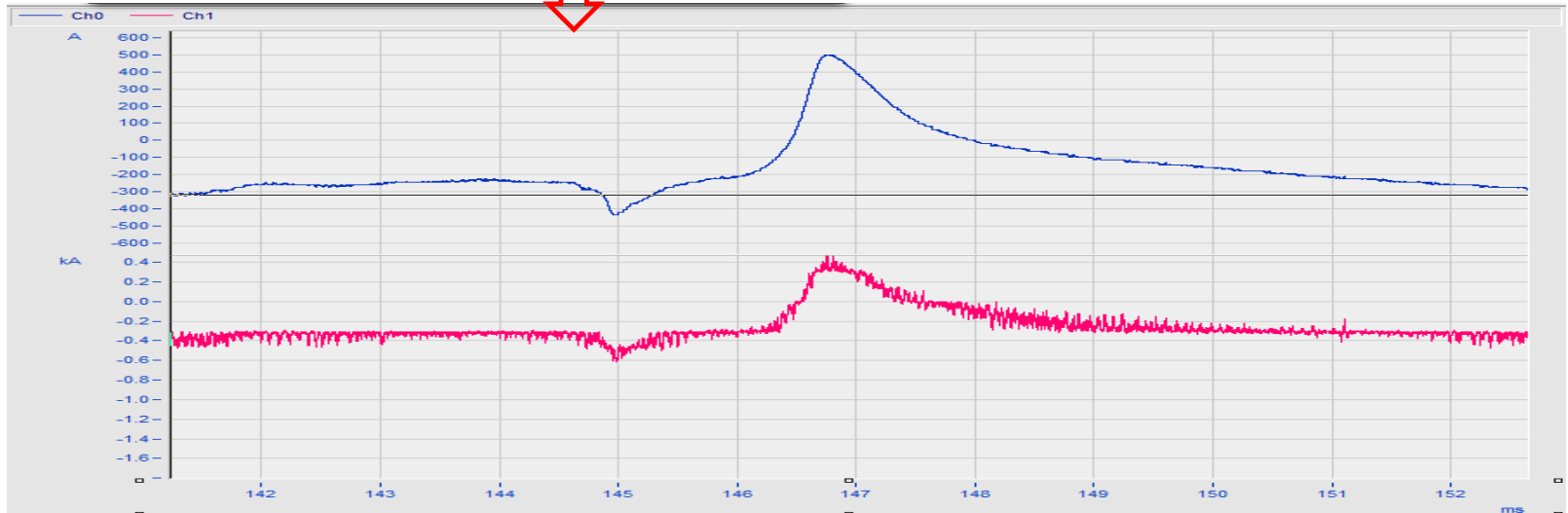
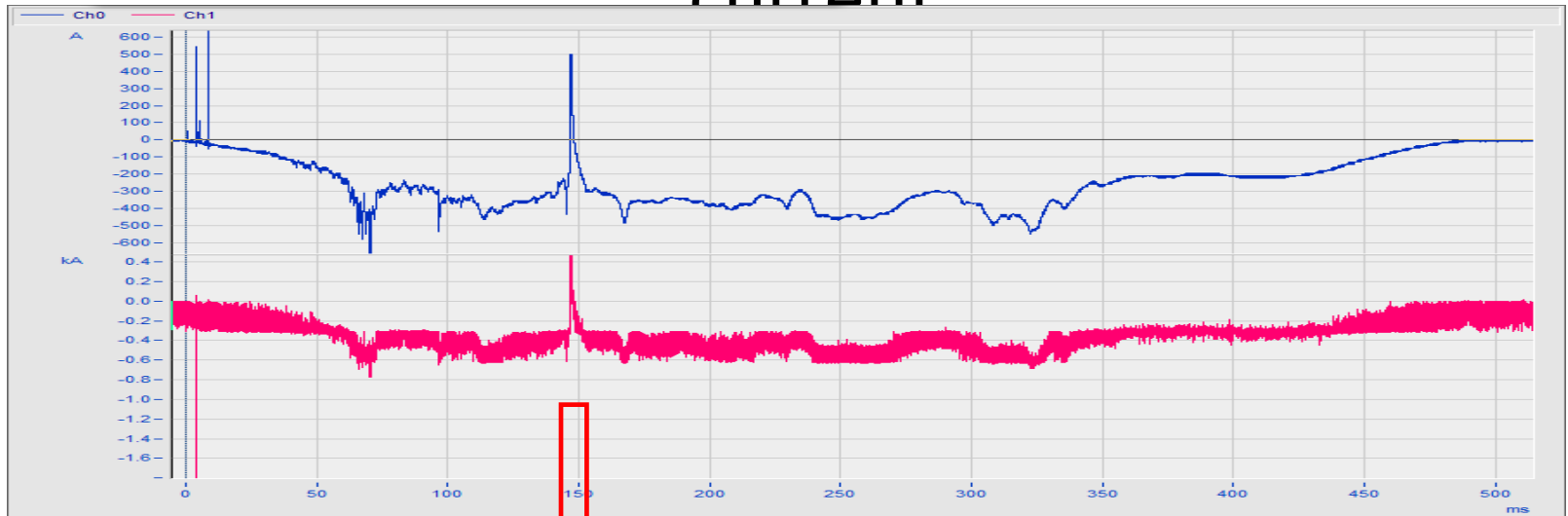
# Outline

- Introduction
- Bipolar Lightning Occurrence Characteristics
- Bipolar Lightning Types Classification
  - Type(i) : Polarity reversal during the Initial Stage (IS) current
  - Type(ii): Different polarities of the IS current and of the following return strokes.
  - Type(iii): Return strokes of opposite polarity.
- Discussion and Conclusions

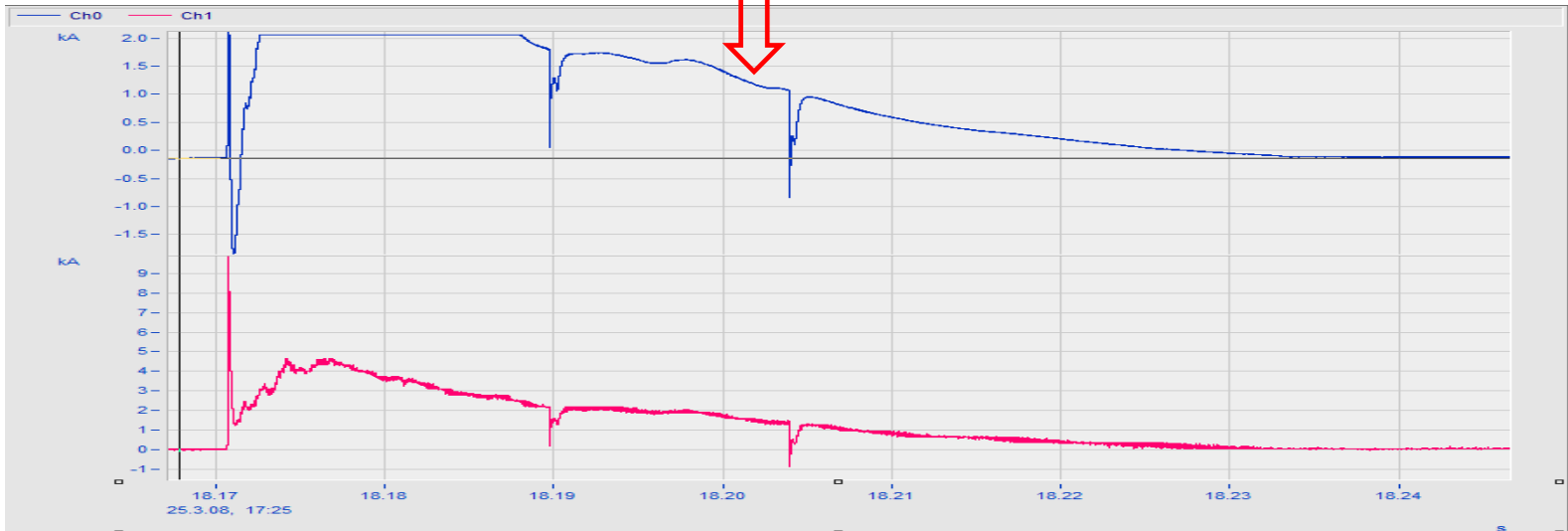
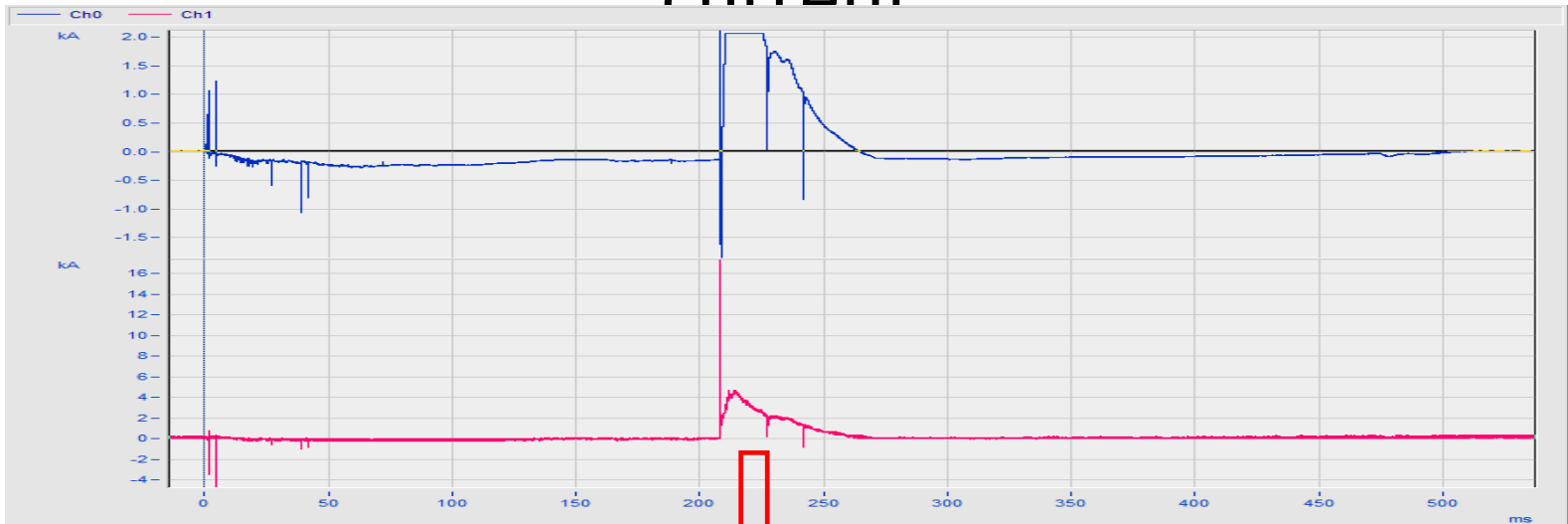
# Bipolar Lightning Types Classification

- Type (i) : 12
- Type (ii) : 4
- Type (iii) : 1
- One bipolar lightning is not classified into above types mentioned.
- Most are Type (i) with **66.7%**

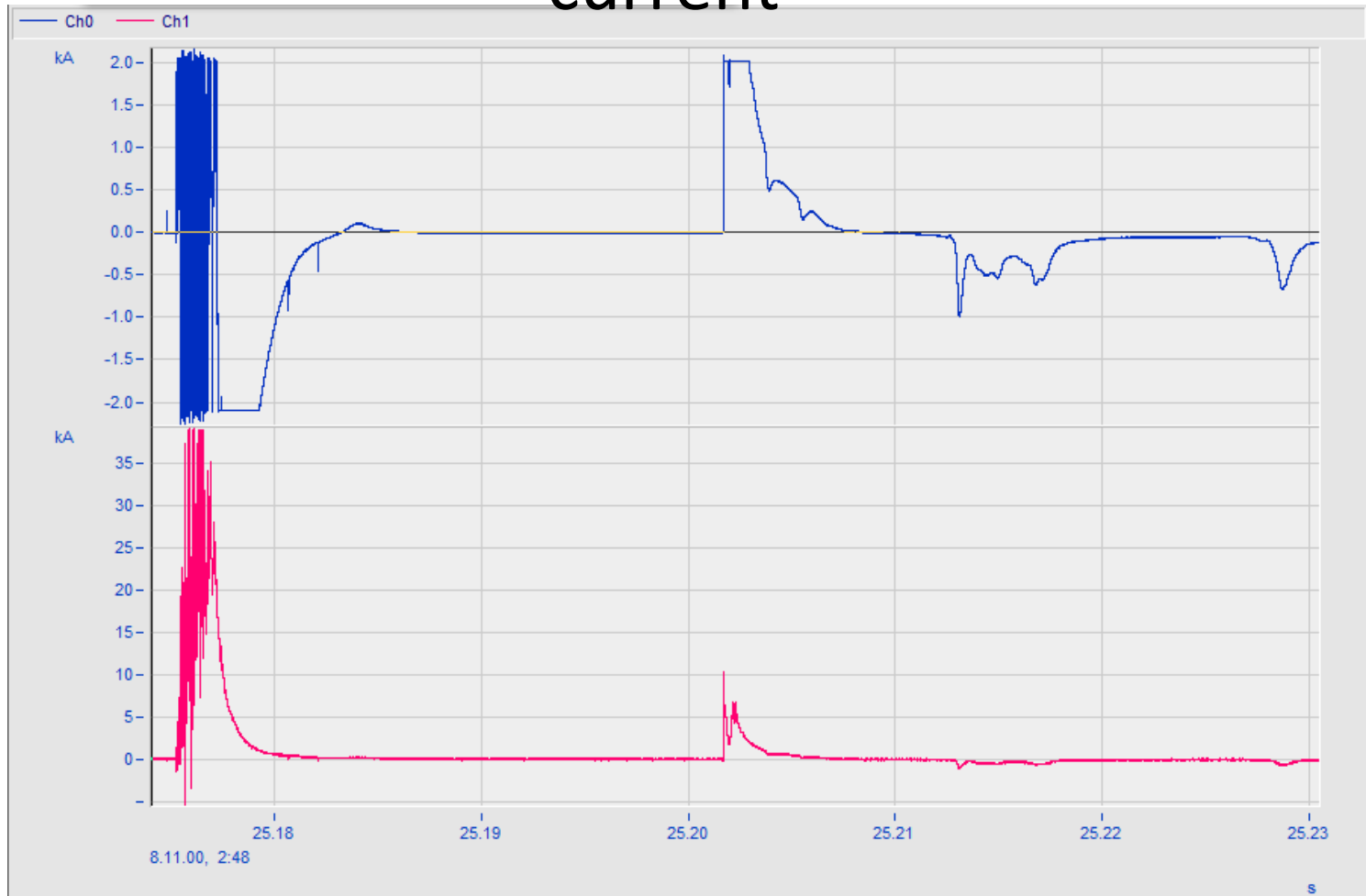
# Type (i) negative current->positive current



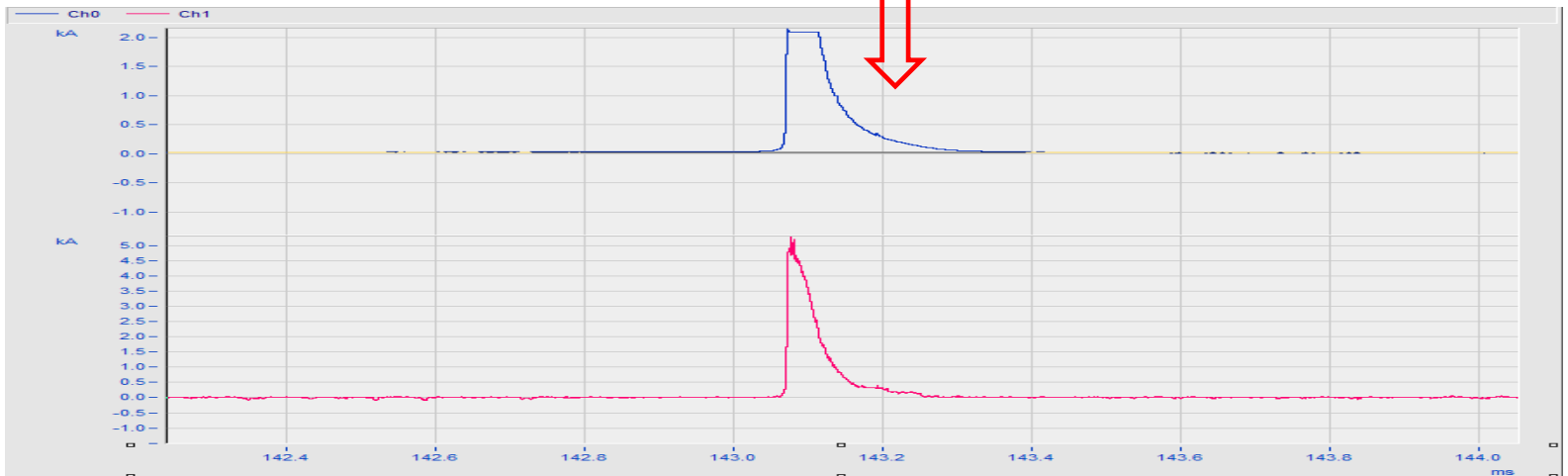
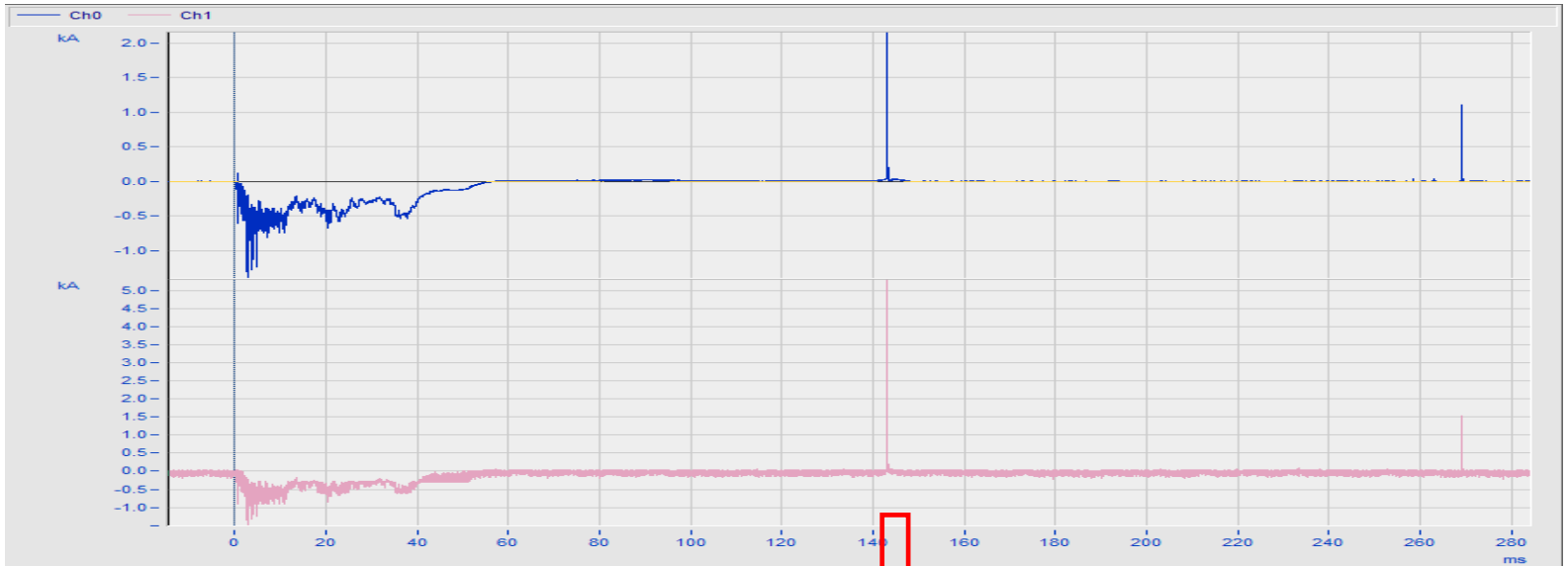
# Type (i) negative current->positive current



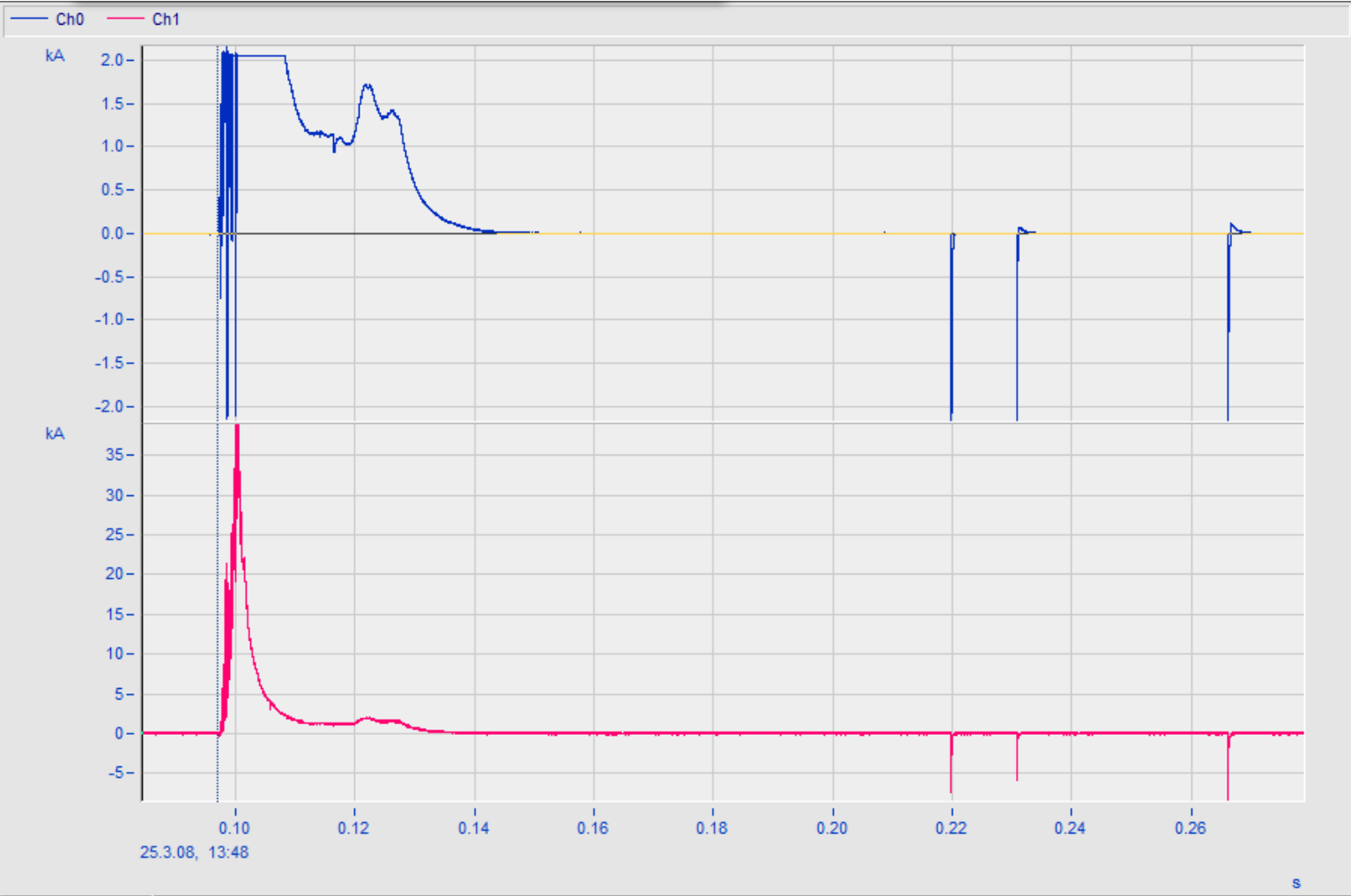
# Type (i) positive current->negative current



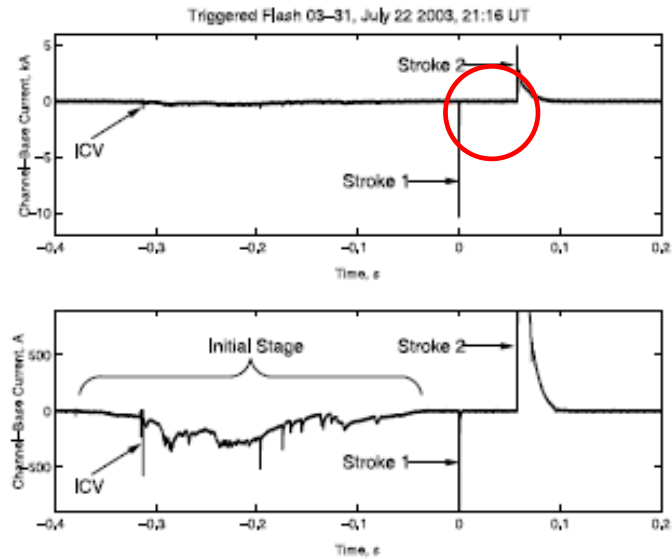
# Type (ii) negative current->positive current



# Type (ii) positive current->negative current



# Type (iii)



Adapted from Jerauld et al. GRL 2004

It's similar to the triggered bipolar lightning.

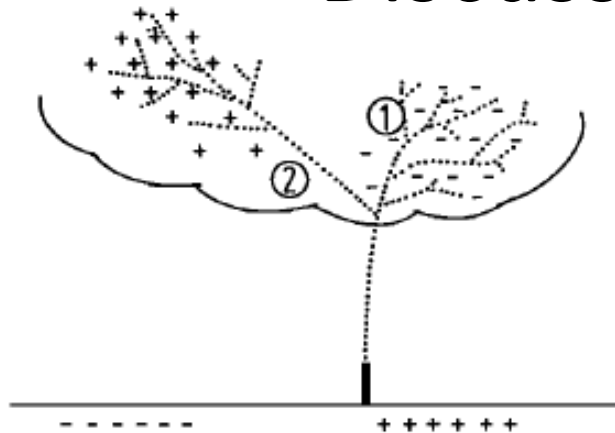
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# Discussion (1)

- Negative current->positive current : 14 ~ 77.8%
- Positive current->negative current: 4 ~ 22.2%
- In Type (i) only **1 of 12** changes polarity from positive current->negative current.
- In Type (ii) **3 of 4** change polarity from positive current->negative current.

# Discussion (2)



Adapted from Narita et al. JGR 1989

Fig. 11. Channel model for the type 1 bipolar lightning; type 2 simply reverses the order of regions 1 and 2.

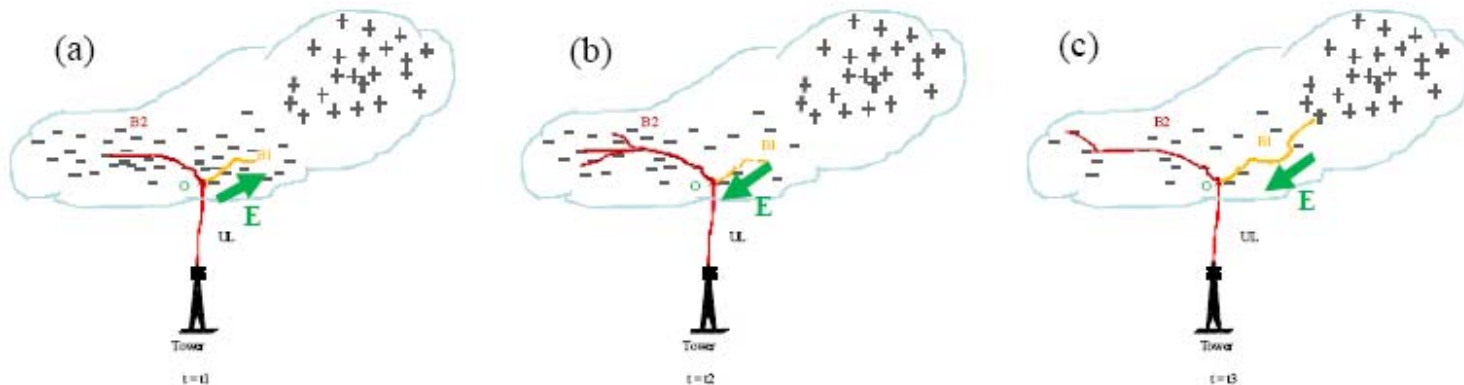
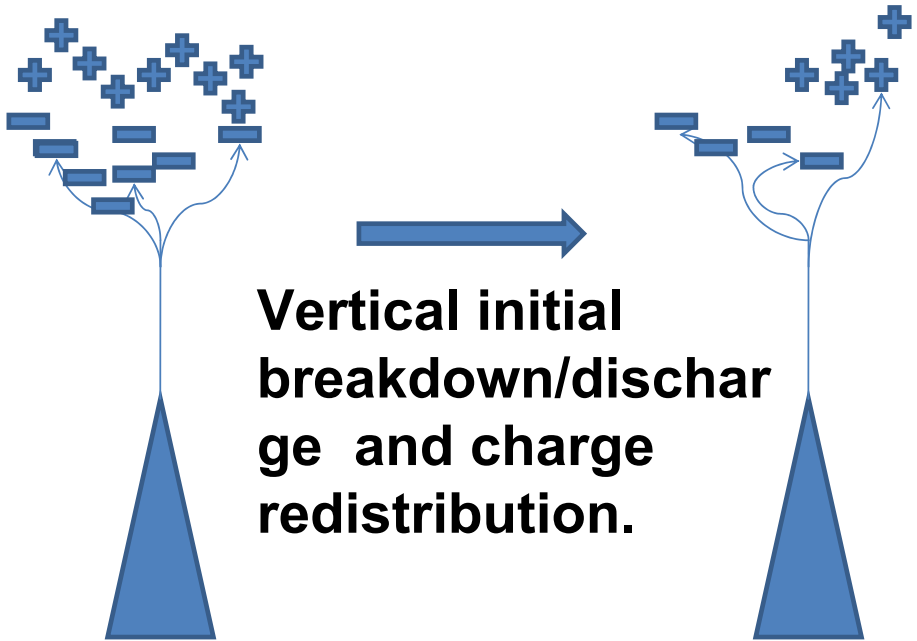
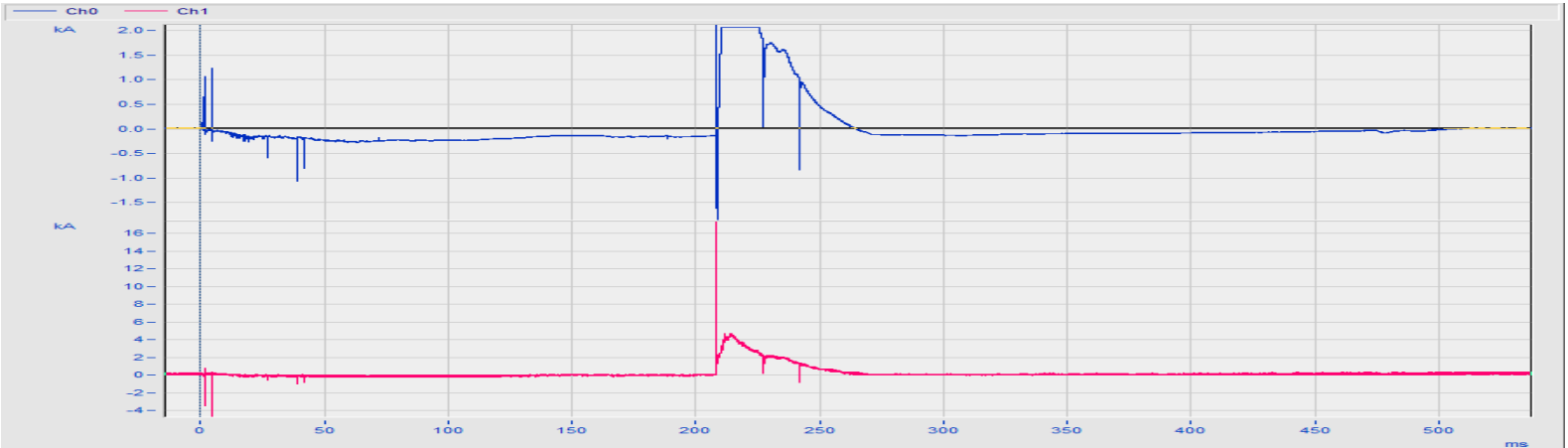


Figure 4 A schematic illustration of a possible scenario of bipolar lightning discharges. Time is from left to right. Adapted from Wang and Takagi URSI 2008.



**Vertical initial  
breakdown/dischar  
ge and charge  
redistribution.**



# Conclusions

- 3% Bipolar lightning occurrence during the 9 years (2000-2008).
- Asymmetrical charge transfer of negative and positive currents.
- The negative and positive charge transfer is opposite to its time duration.
- Most bipolar lightning are type (i) and most change polarity from negative current to positive current .

Thank you for your attention!