

A gamma-ray glow terminated by leader development of an inter-cloud discharge in Japanese winter thunderstorm

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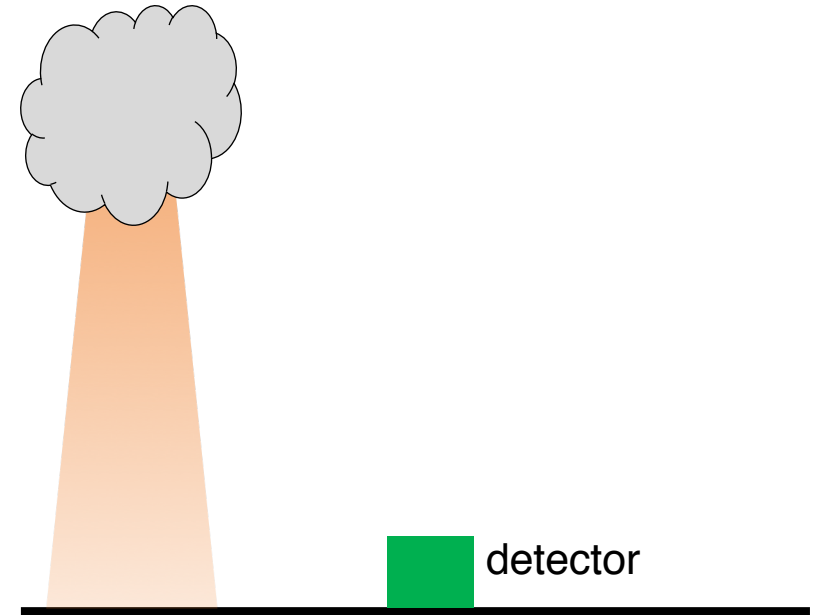
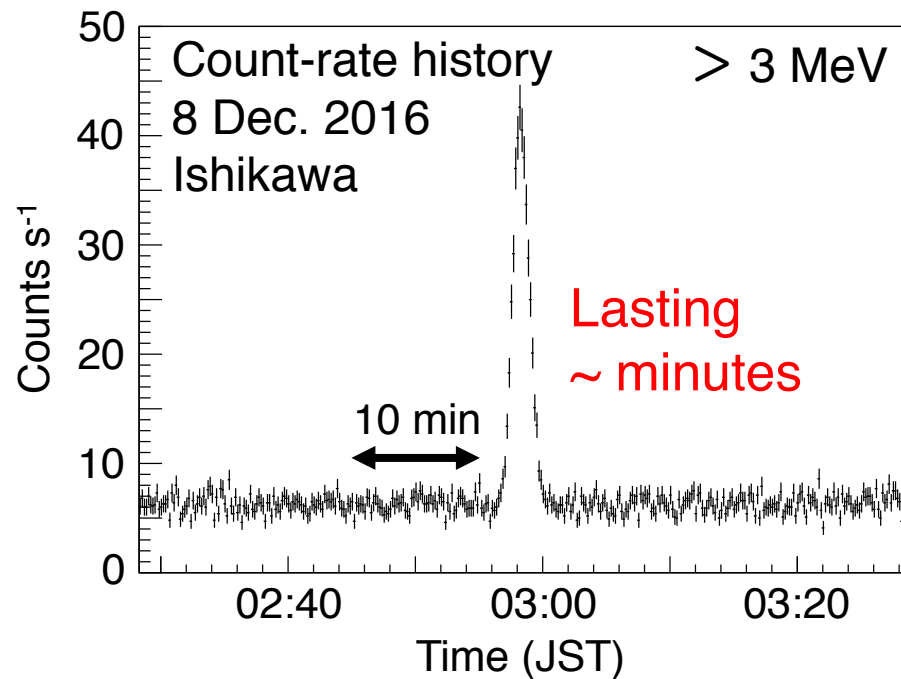
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6: Kobe City College of Tech., 7: Kindai Univ., 8: UCSC, 9: Nagoya Univ., 10: JAEA

Wada et al., GRL, submitted

Gamma-ray glows: stable electron acceleration

- Long-duration gamma-ray bursts associated with passage of a thundercloud.

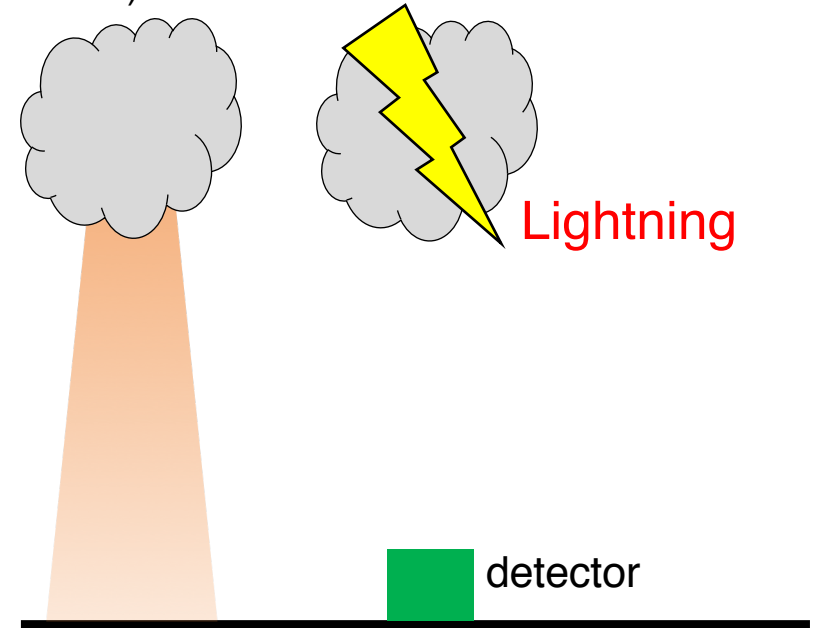
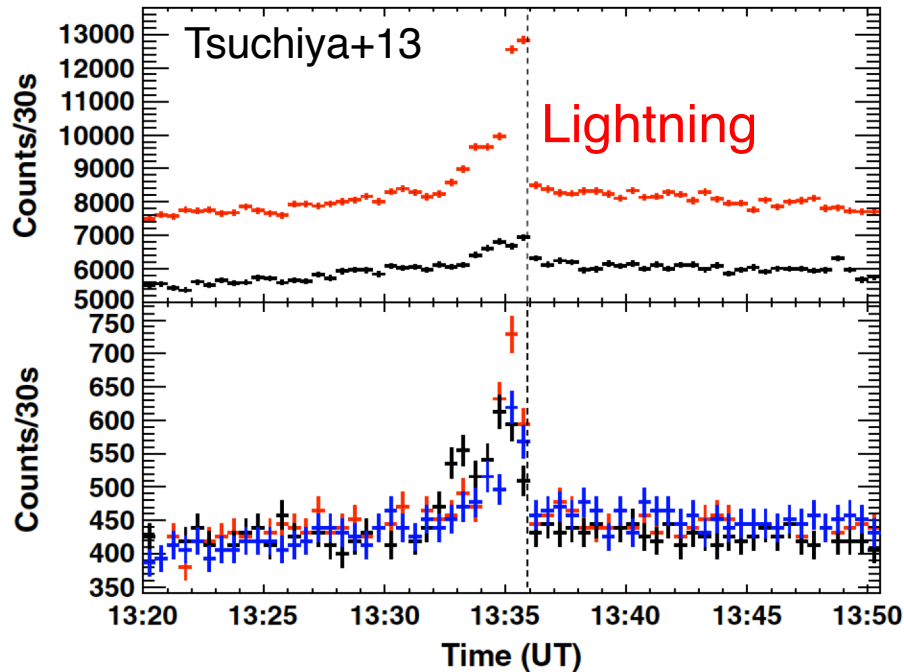


- Gamma-ray glow detection by
 - airborne experiments (McCarthy & Parks 85, Eack+96, Kelley+15)
 - mountain-top experiments (Moore+01, Chilingarian+10, 11, 16, Torii+09, Tsuchiya+12)
- Observations in Japanese winter thunderstorms
 - Low cloud-base altitude, large discharge current, powerful activity.
 - > Suitable for on-ground gamma-ray observation. (Torii+02,11, Tsuchiya+07,11,13, Kuroda+16)

Gamma-ray glow termination by lightning

- Gamma-ray glows are sometimes terminated with lightning.

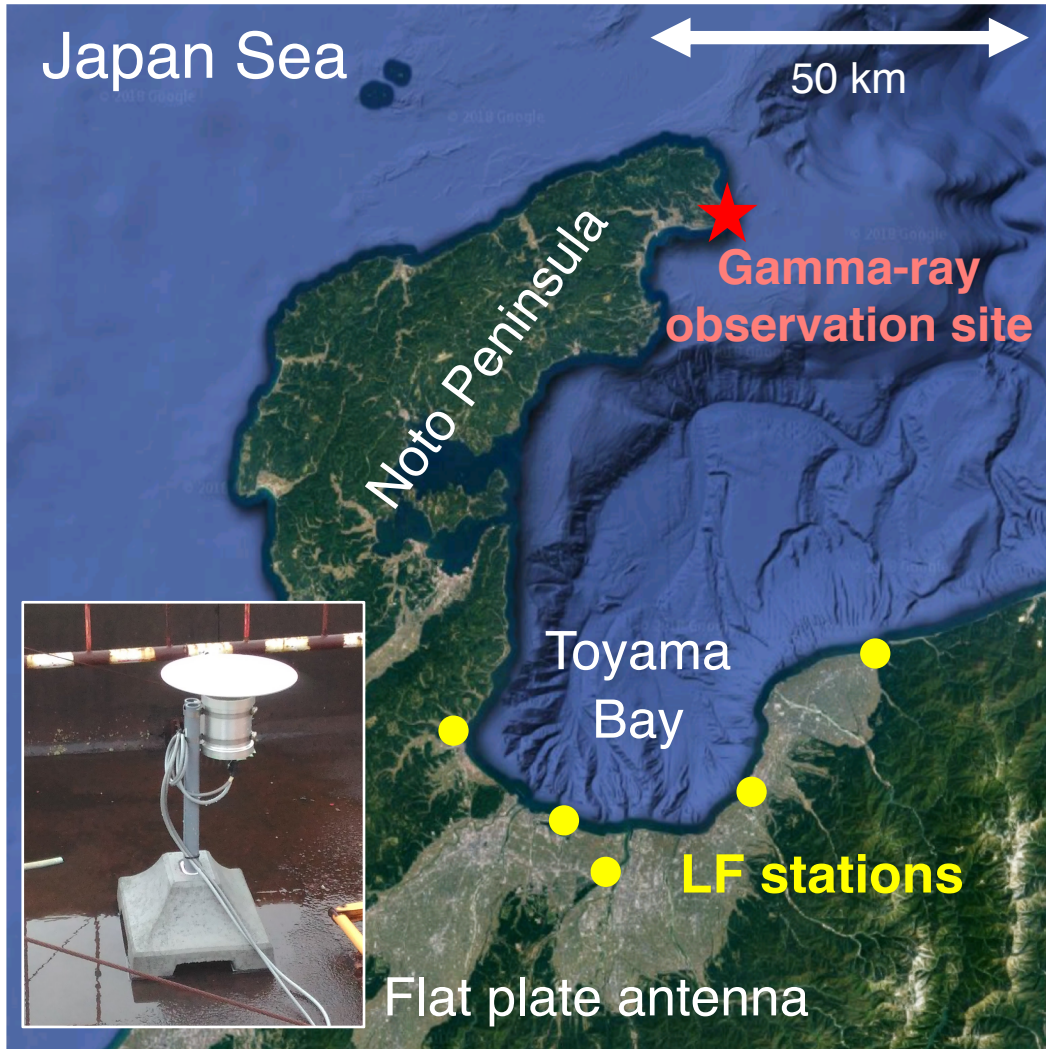
(McCarthy & Parks 86, Tsuchiya+13, Kelley+15, Chilingarian+17)



- Lightning itself can be detected by radio monitors.
 - > Radio monitors can be the “forth eye” to observe glows. (besides gamma-ray, electric-field monitors and radar)
- 2D/3D mapping of lightning processes (e.g. lightning mapping array).
 - > Does a combination of gamma-ray, electric-field, radar and radio observations provide us clues to understand gamma-ray glows?

On-ground observation in Noto Peninsula

- Two gamma-ray monitors and an electric field monitor in Noto Peninsula
- Low frequency radio monitor network along Toyama Bay (LF: 800 Hz - 500 kHz)



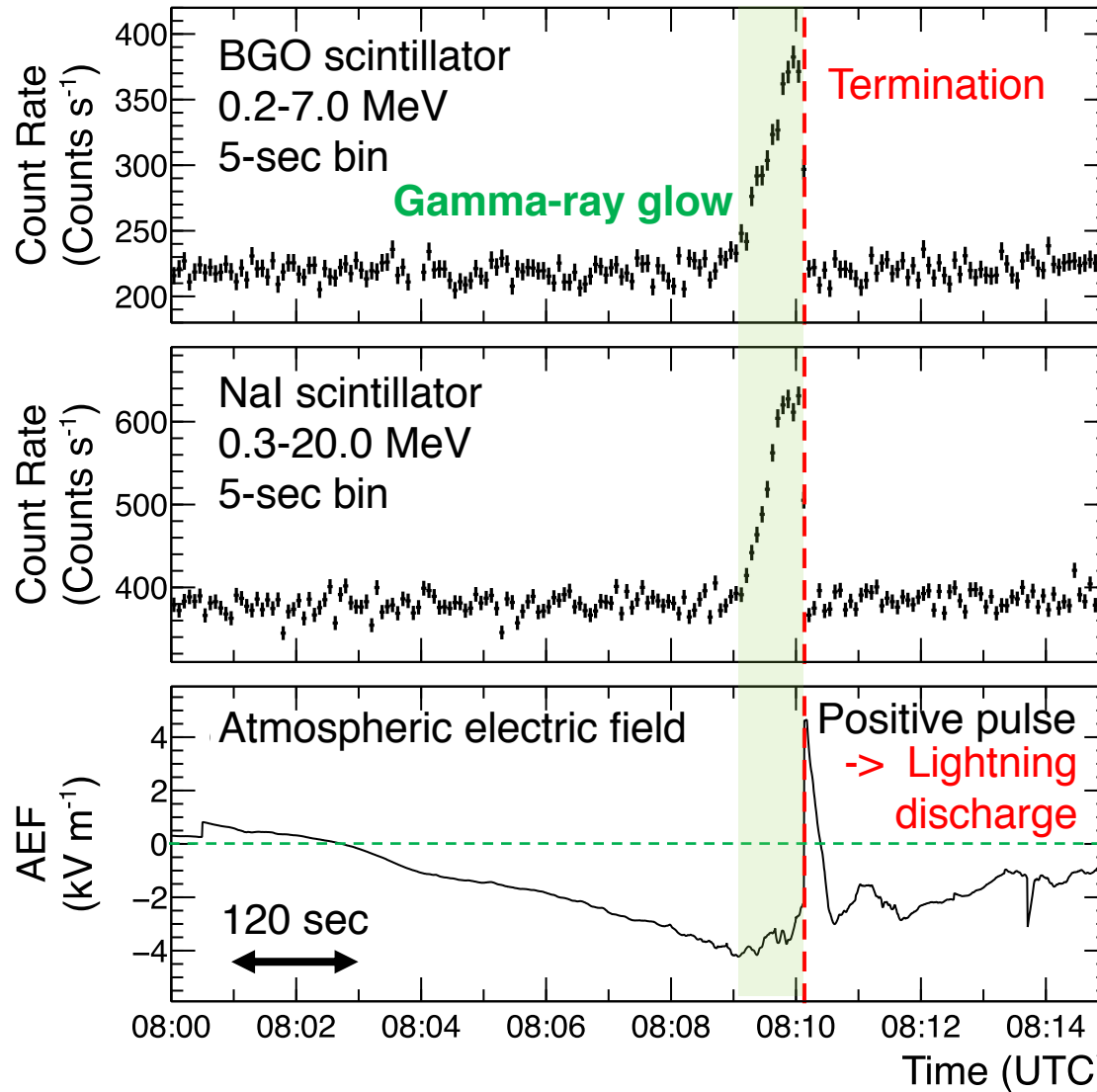
GROWTH detector (Enoto+17)
- 3 inch BGO scintillator



GODOT detector (Bowers+17)
- 5 inch NaI scintillator



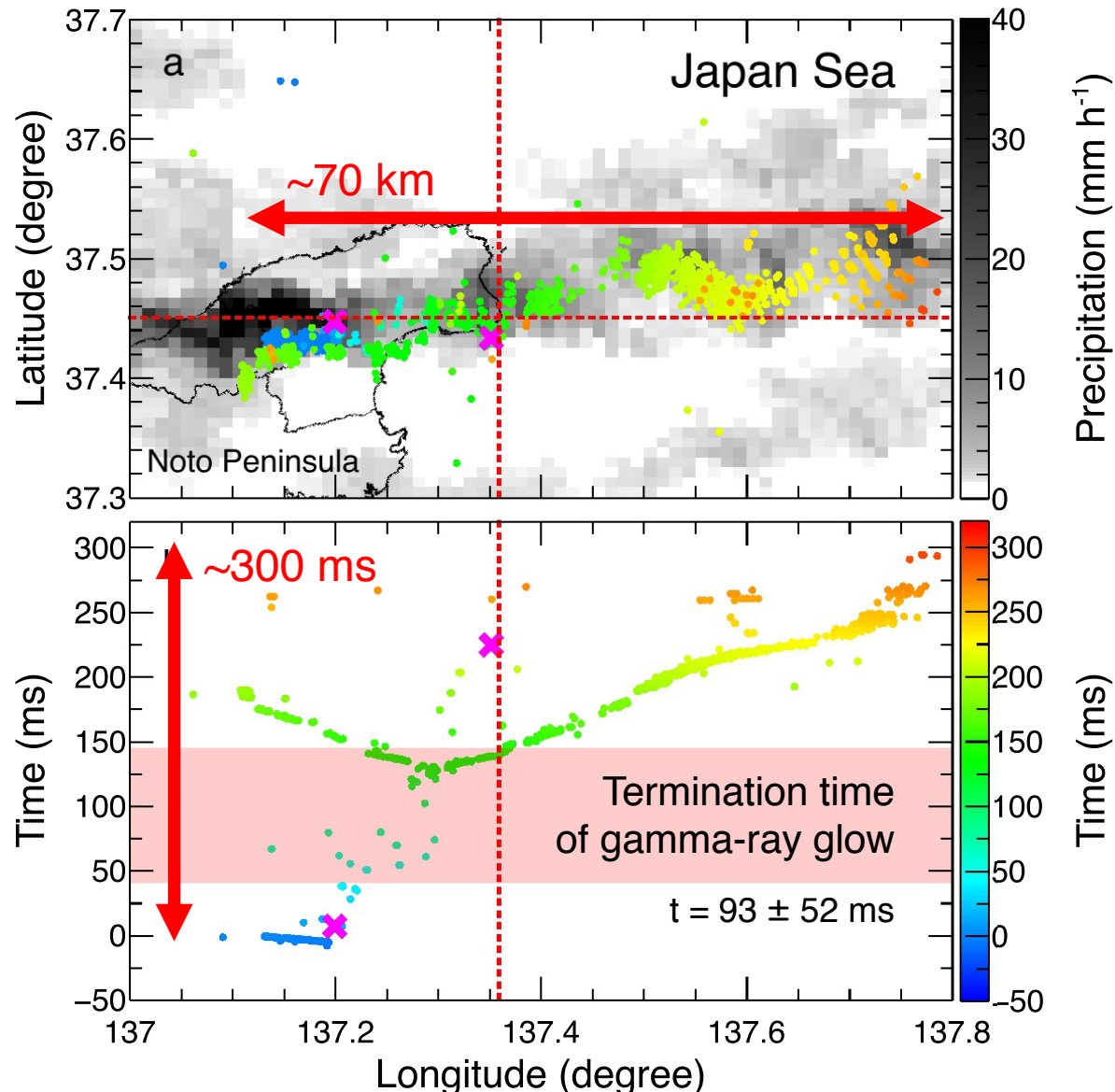
Gamma-ray glow event on 11th Feb. 2017



Gamma-ray monitors detected a gamma-ray glow termination event.

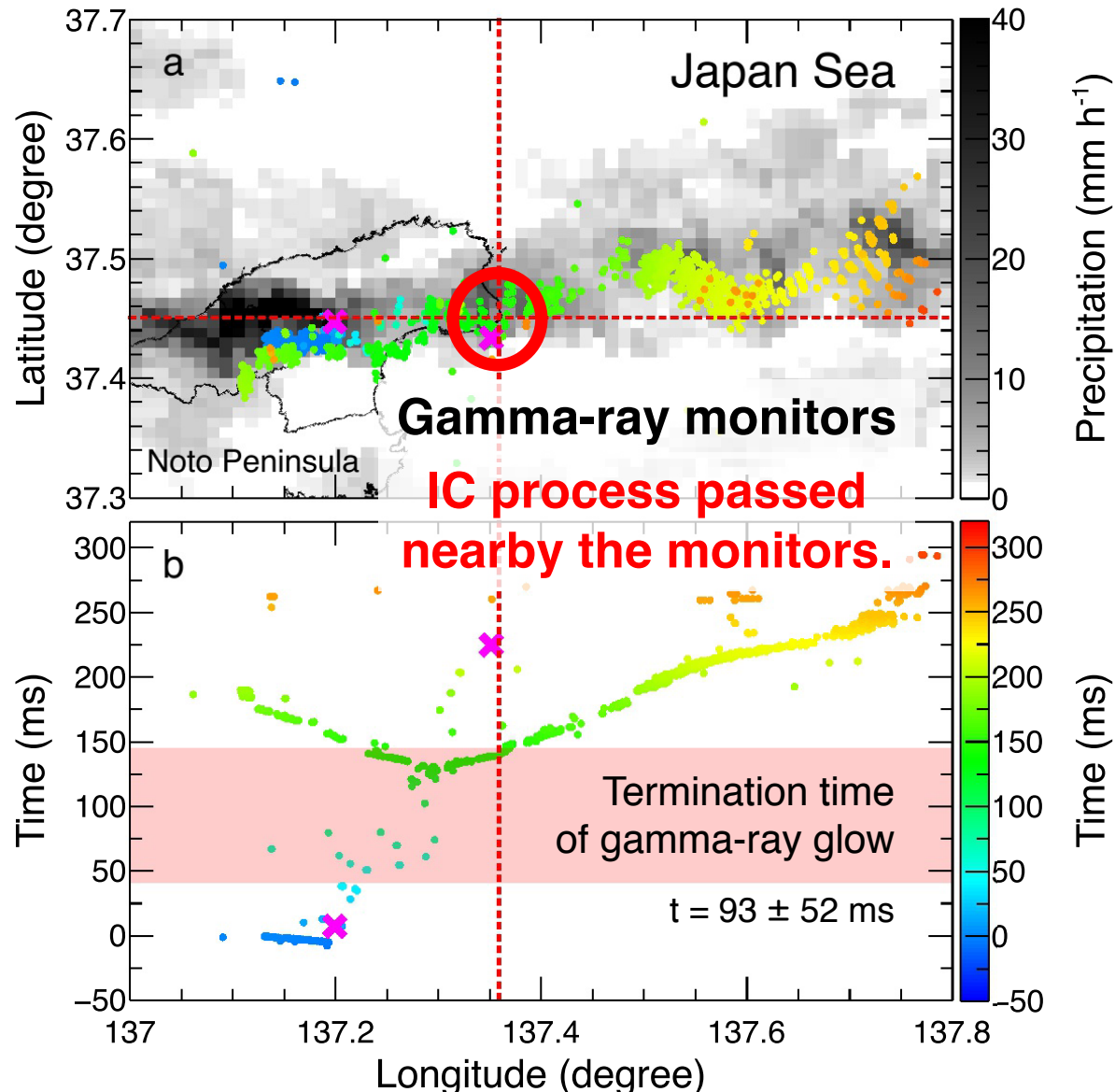
Lightning Mapping with LF monitoring stations

- LF network detected leader development of an IC.



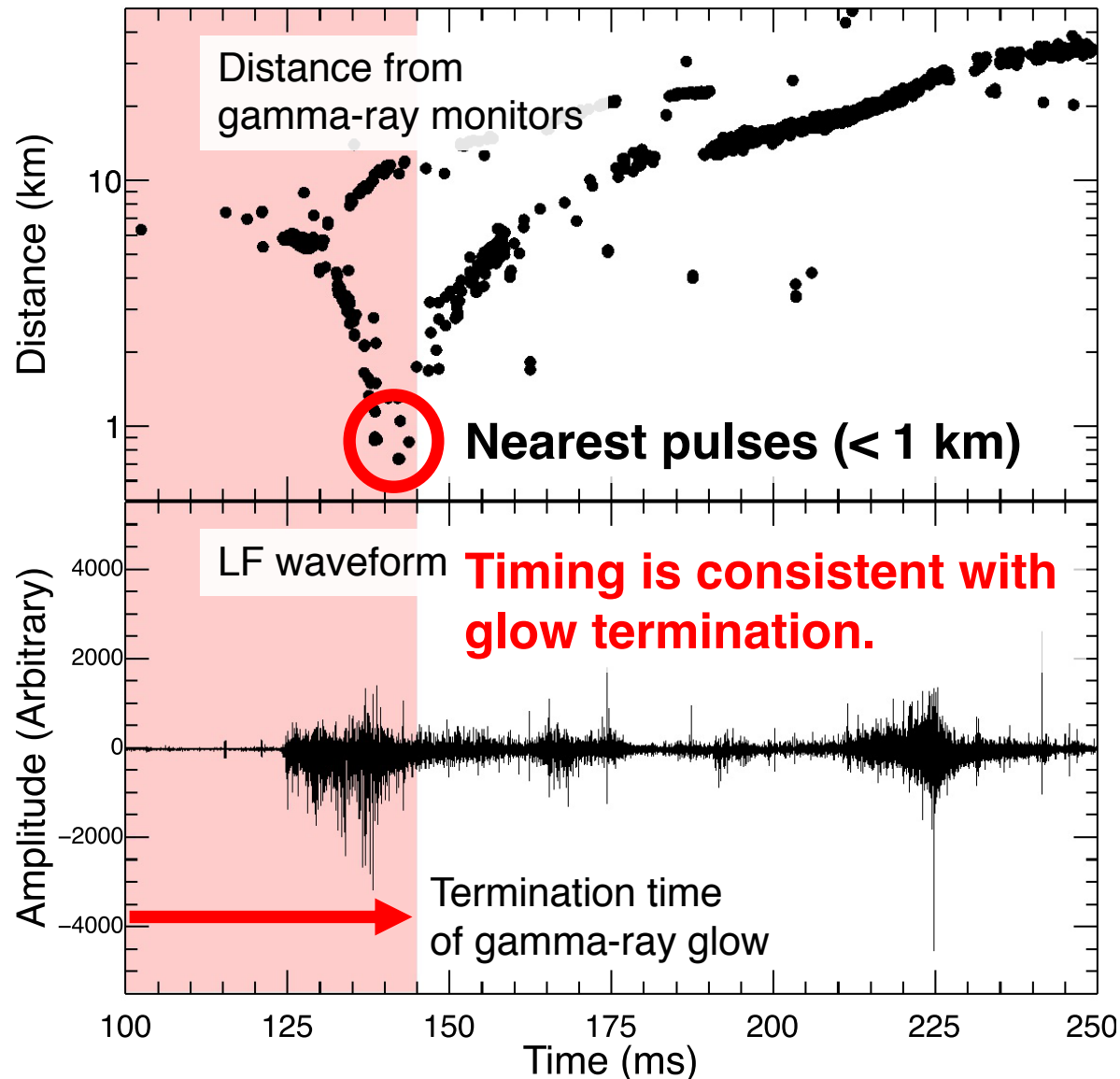
Lightning Mapping with LF monitoring stations

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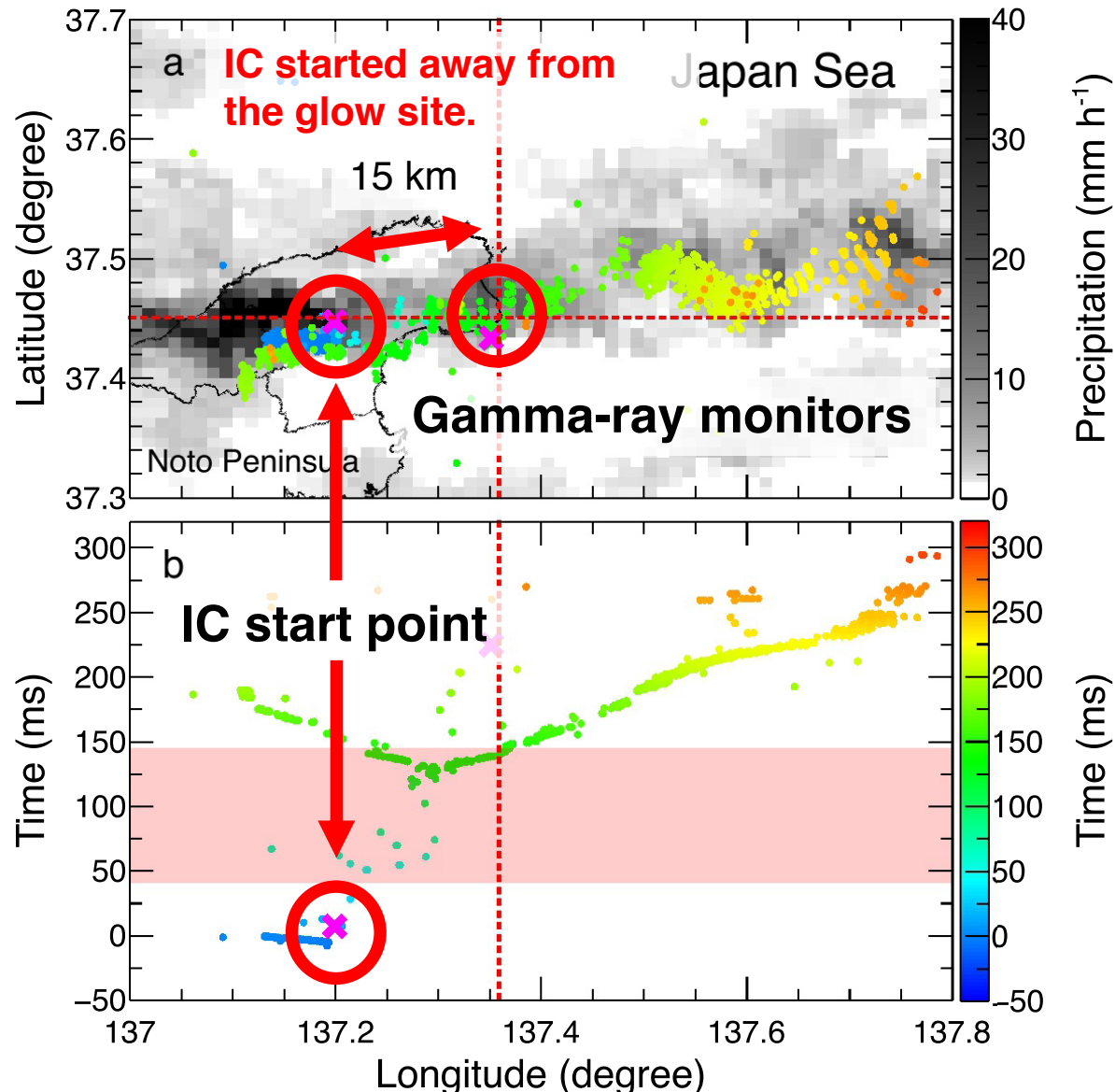
Lightning Mapping with LF monitoring stations

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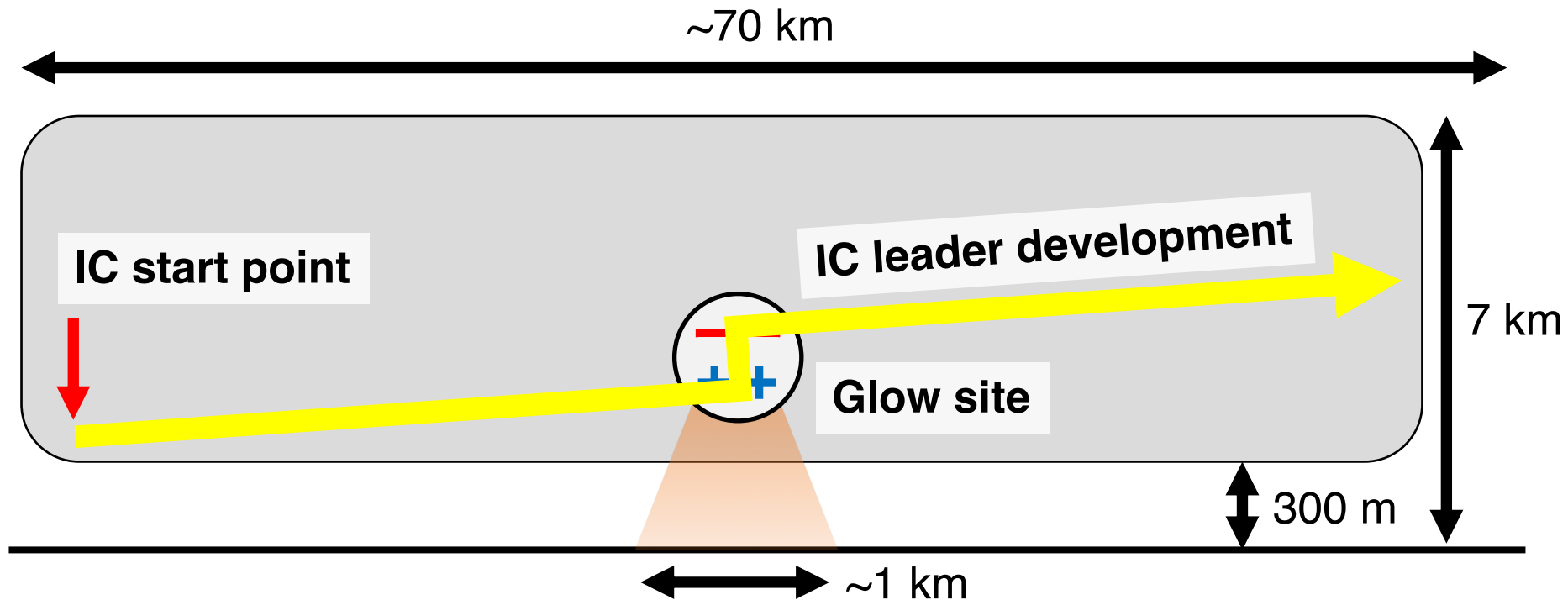
Lightning Mapping with LF monitoring stations

- LF network detected leader development of an IC.



Discussion

- Relativistic Runaway Electron Avalanche process (Grevich+92, Dwyer+12) should be developed in thundercloud.
 - > Accelerated and multiplied electrons emit gamma rays.
- A part of the IC processes passed nearby the glow site.
 - > Destroyed the RREA process, then terminated the glow.
- The IC started away from the glow site, prior to the glow termination.
 - > The glow did not initiate the IC in this case.



Conclusion

- We performed observation of Japanese winter thunderstorms with gamma-ray, electric-field and LF-band radio monitors.
- Gamma-ray monitors at the top of Noto Peninsula observed a gamma-ray glow termination event on 11th February 2017.
- Electron-acceleration mechanism was destroyed by IC processes passing nearby the gamma-ray observation site.
- The IC started away from the gamma-ray glow site. The glow did not initiate the IC in this case.

Winter thunderstorms in Japan provide us fruitful scientific results of both gamma-ray glows and TGFs / photonuclear reactions!