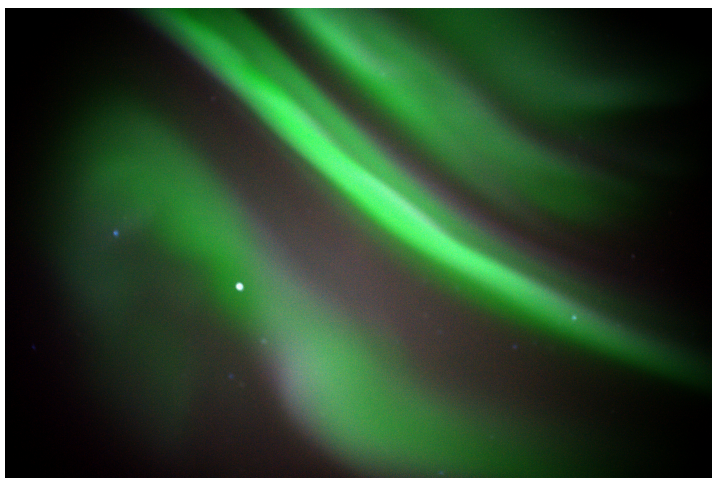
Vlasov simulations and the MOMA project

Herbert Gunell

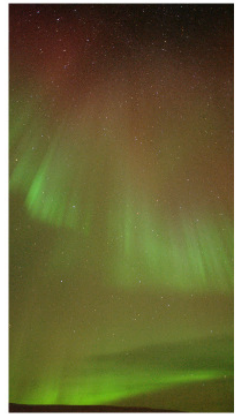
Belgian Institute for Space Aeronomy, Brussels, Belgium

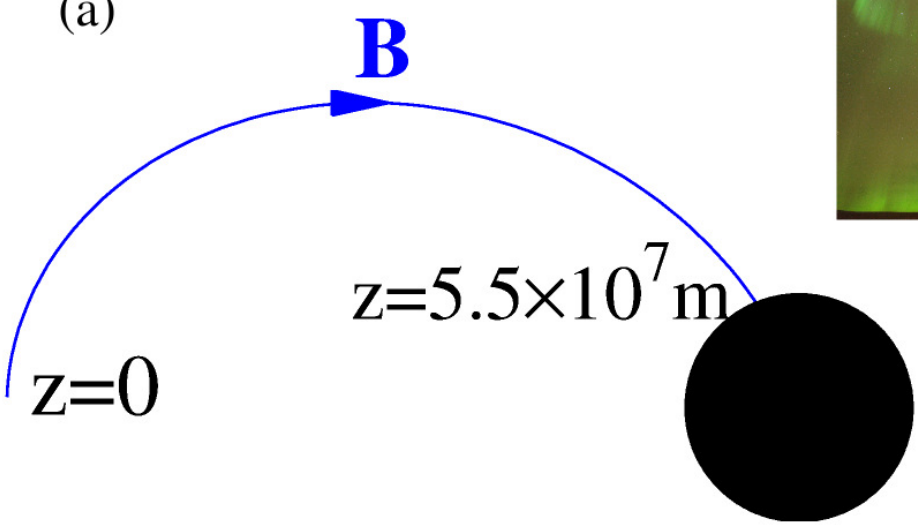


Simulation model

The distribution function is $f_s(z, v_z, \mu)$ and the Vlasov equation

$$\frac{\partial f_s}{\partial t} + v_z \frac{\partial f_s}{\partial z} + \frac{1}{m_s}\left(q_s E - \mu \frac{\partial B}{\partial z} + m_s a_g\right)\frac{\partial f_s}{\partial v_z} = 0$$





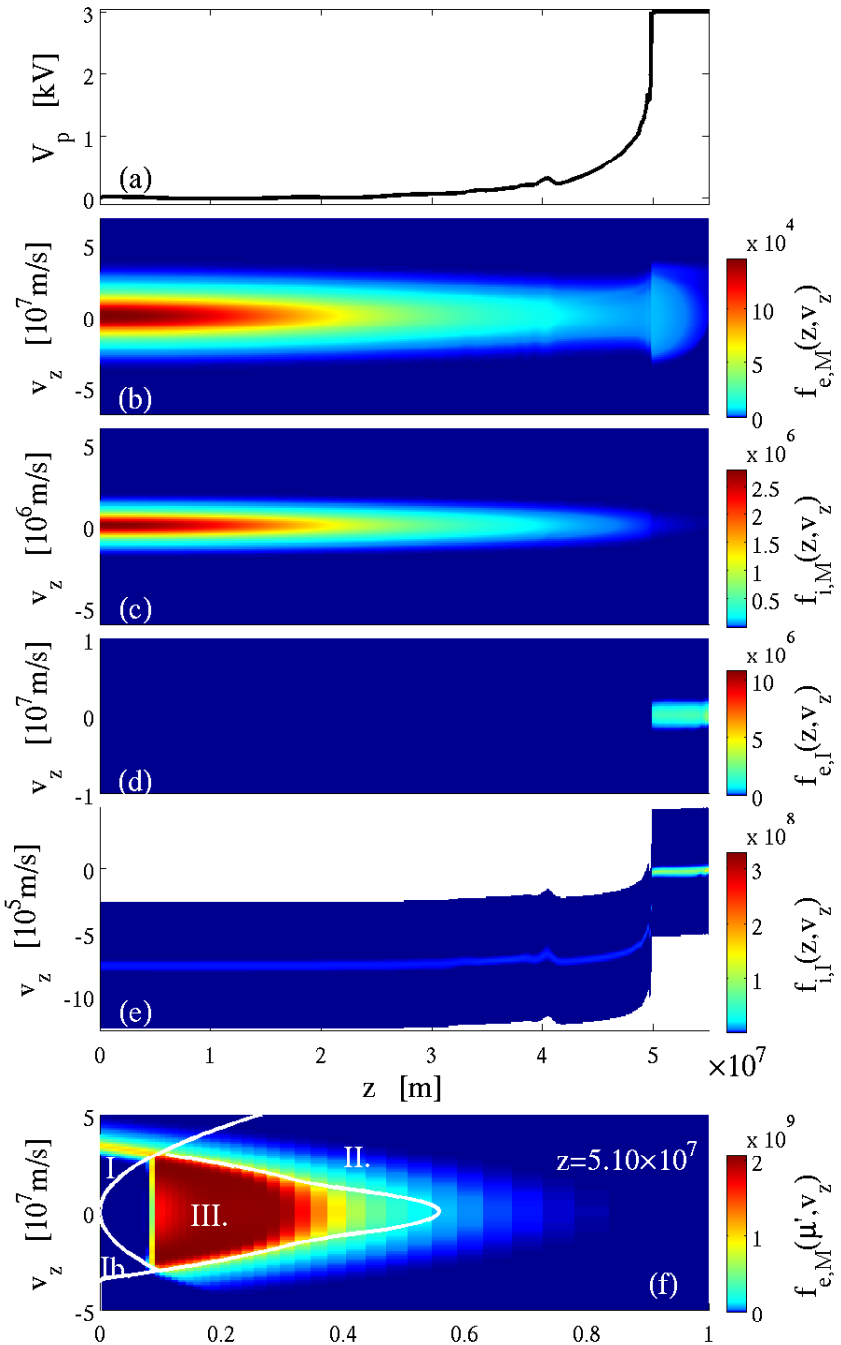
$$\mu = \frac{m_s v_\perp^2}{2B}$$

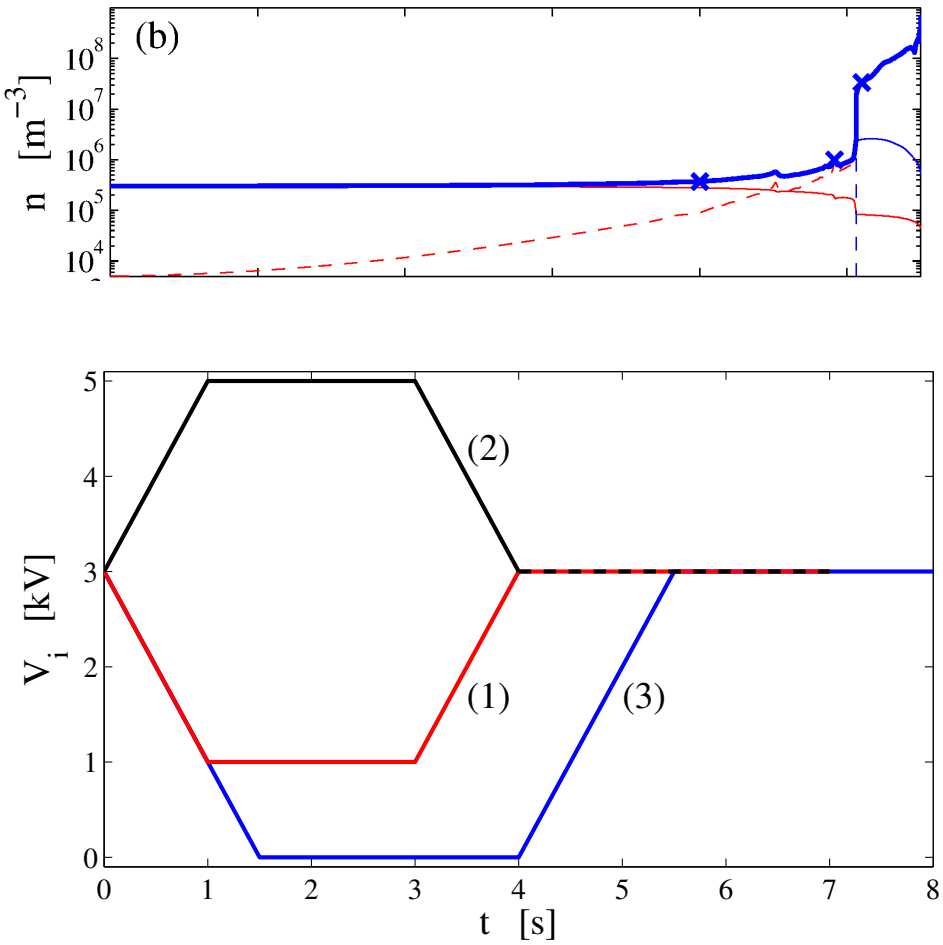
is a constant of motion. The electric field is given by

$$\frac{d}{dz}\left(\frac{B_S}{B}E\right) = \frac{\rho_I}{S\epsilon}$$

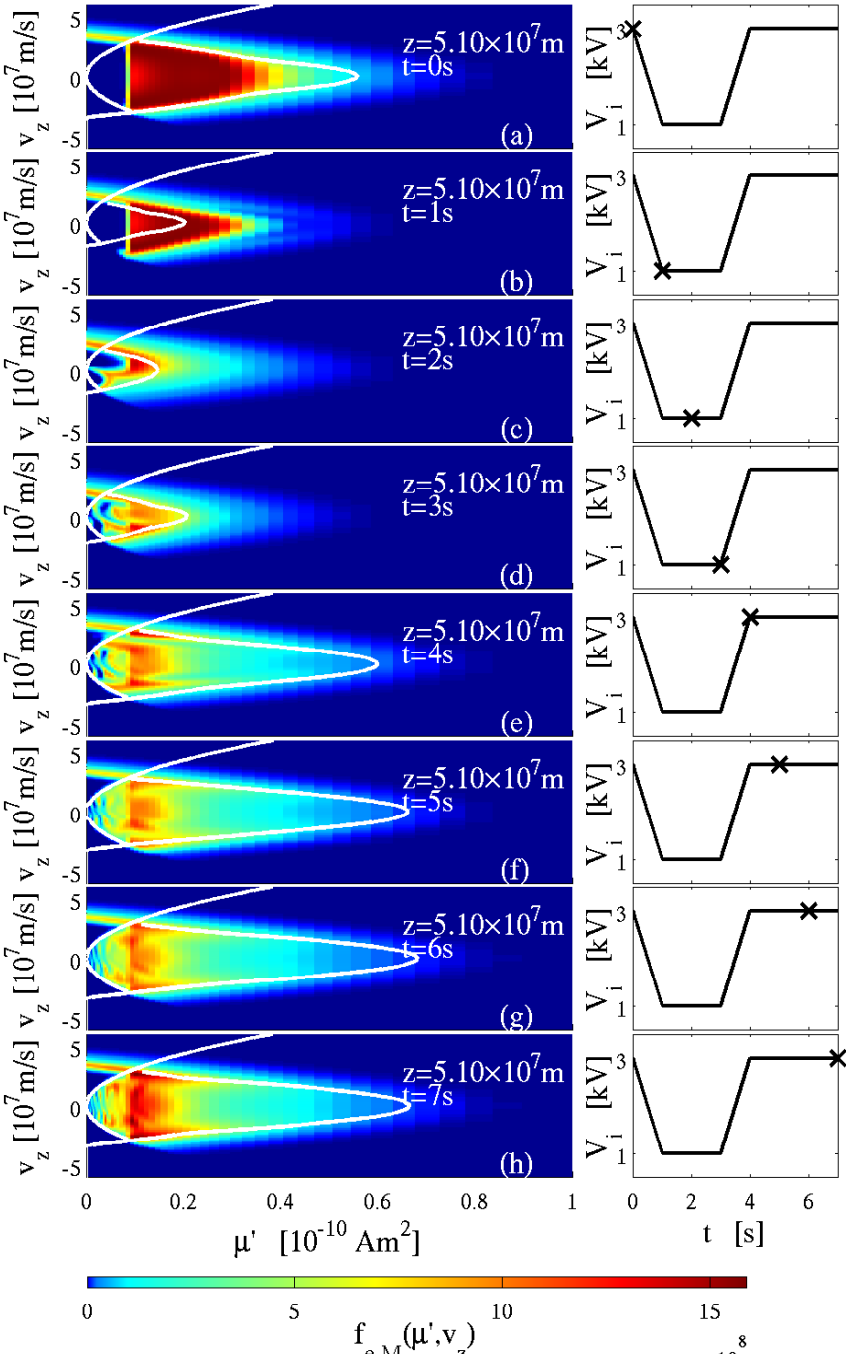
Computer code published by Gunell et al. (2013a)

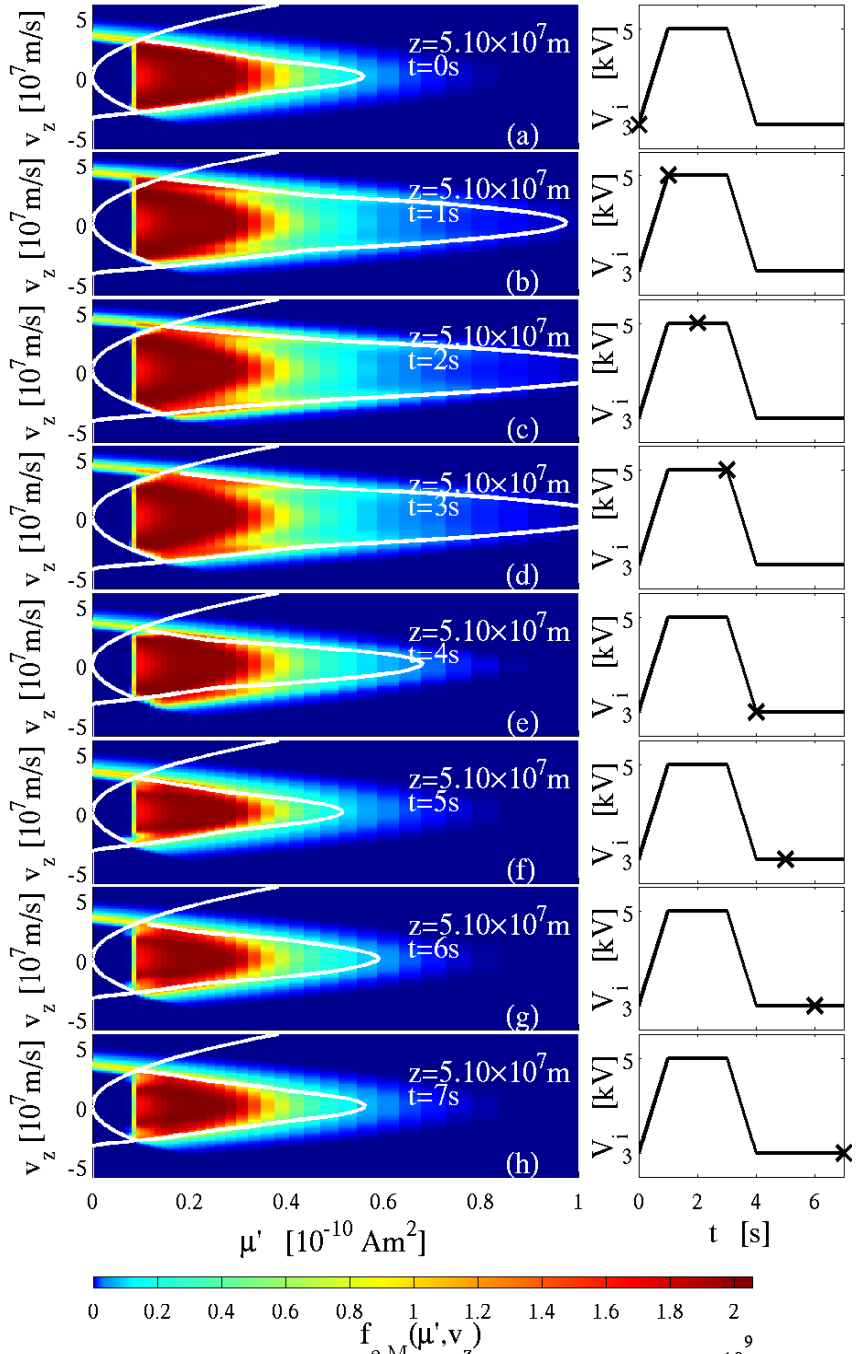
Upward current region — numerical experiments



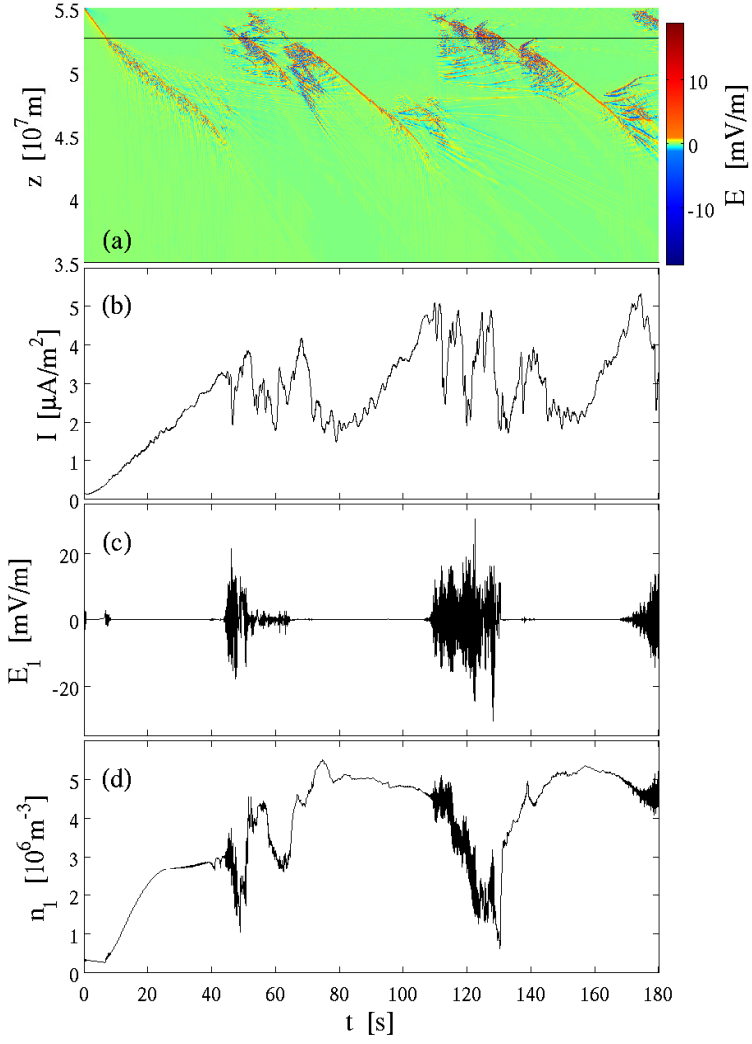


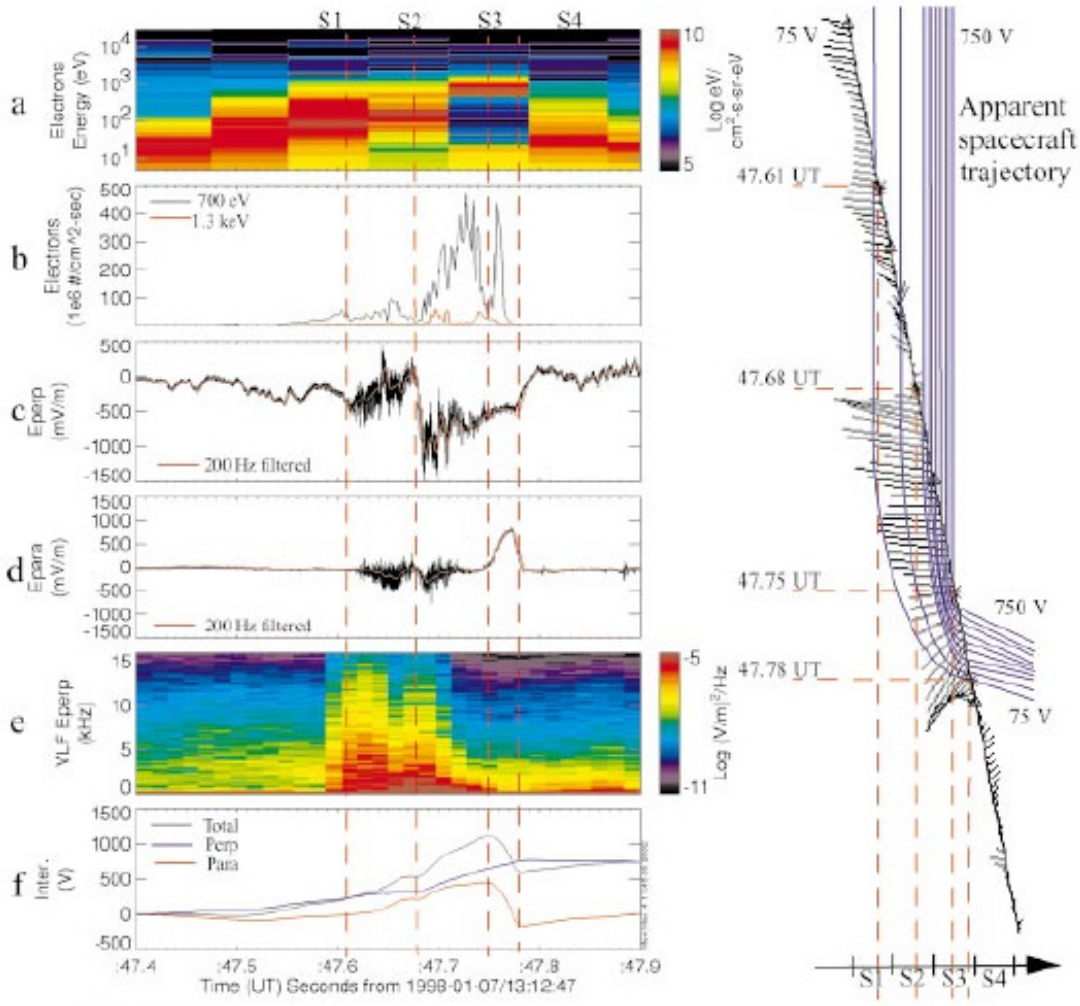
$f(\mu, v_z)$ at $z = 5.1 \times 10^7$ m (Gunell et al., 2015b)





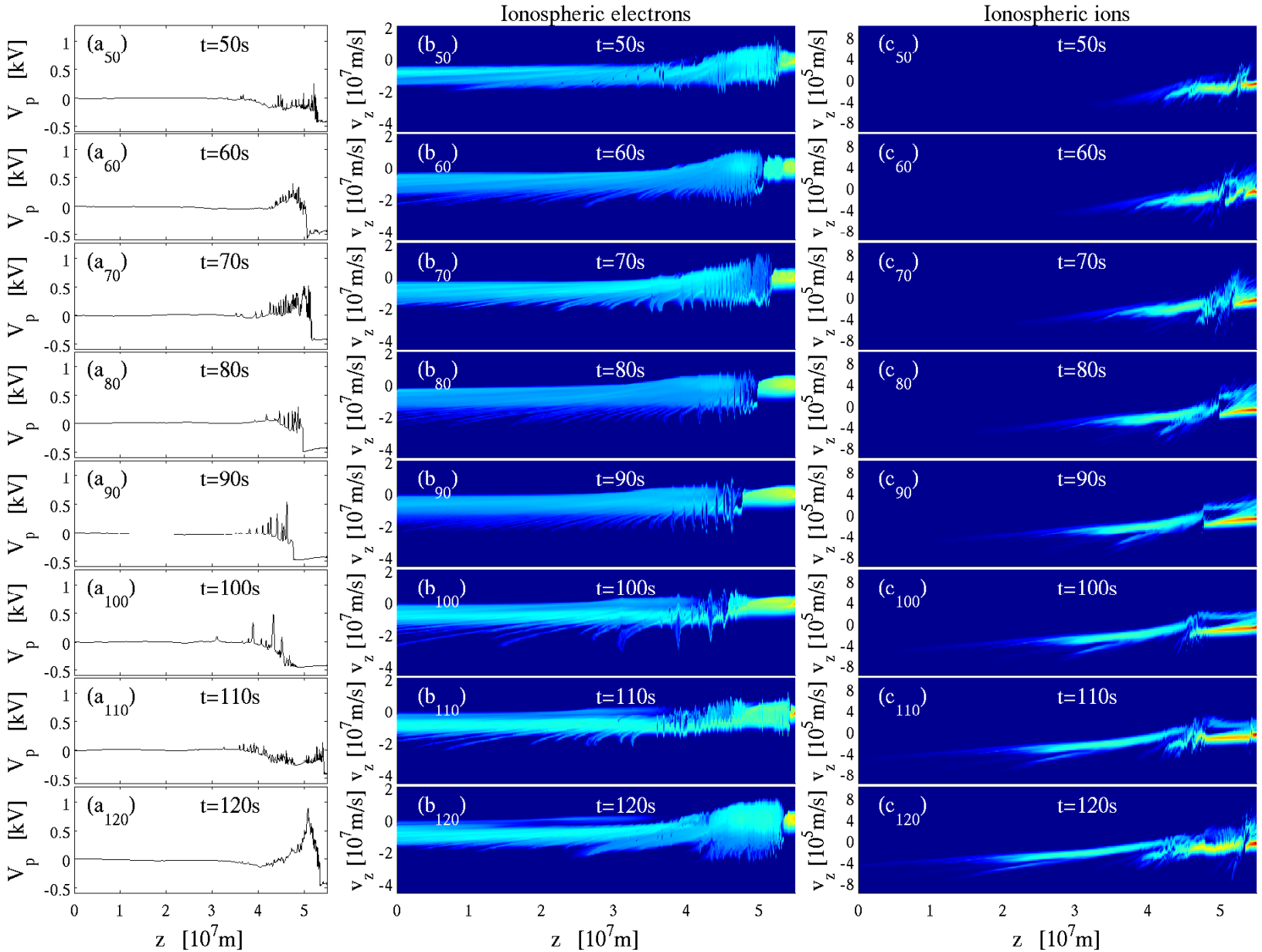
Downward current region (Gunell et al., 2015a)





Left: simulations. Right: FAST observations (Andersson et al., 2002).

Double layer motion



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Extensions within MOMA

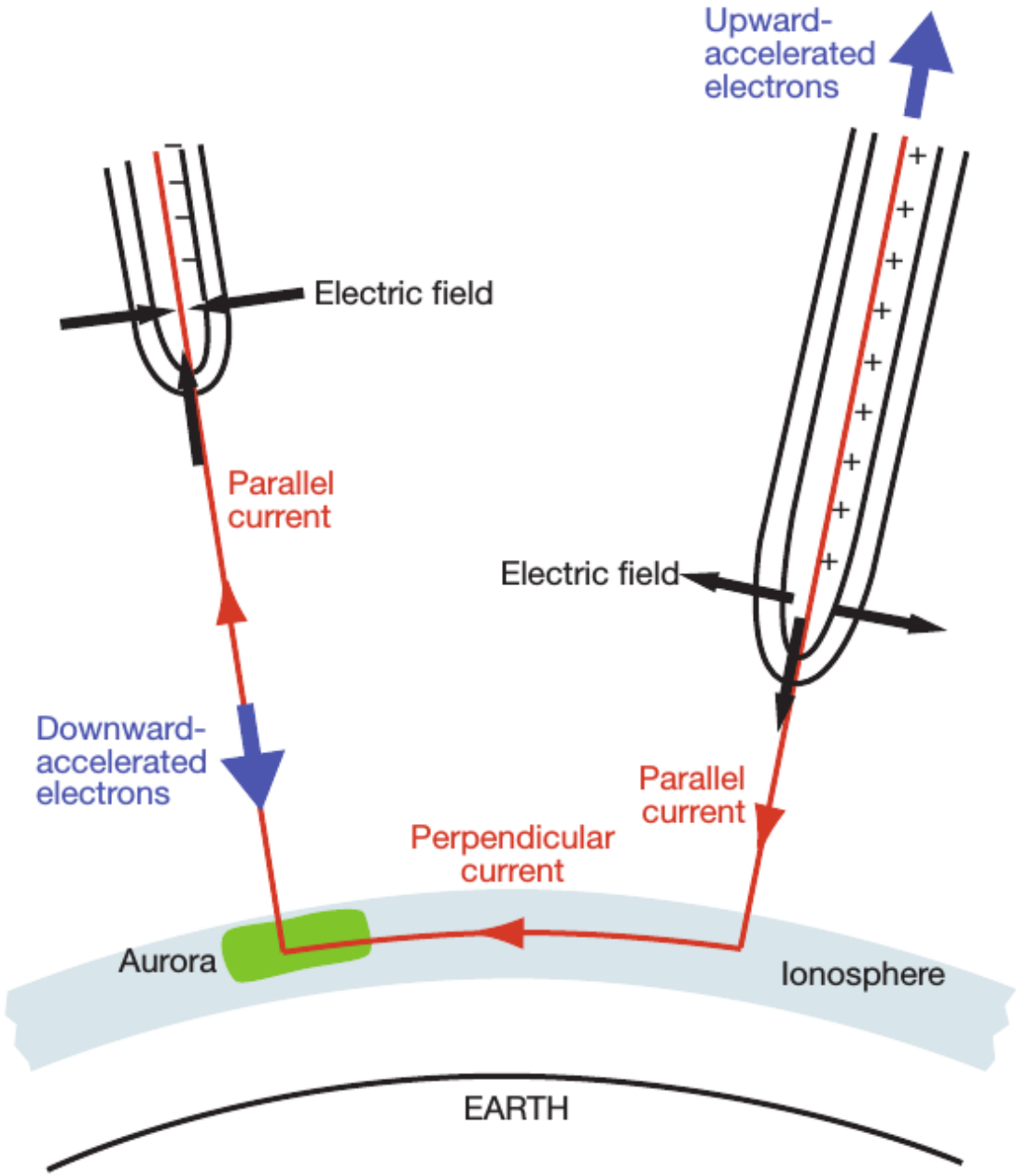
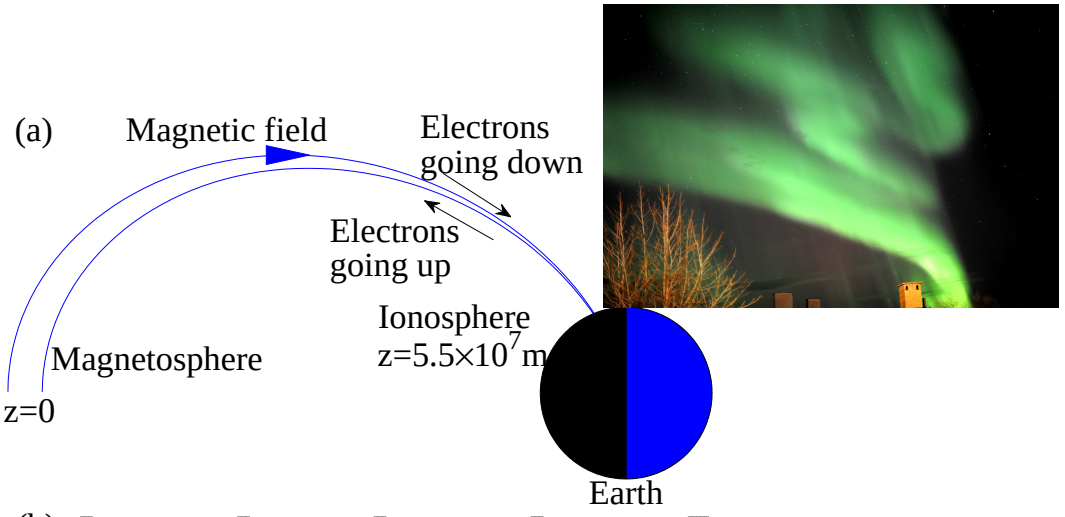
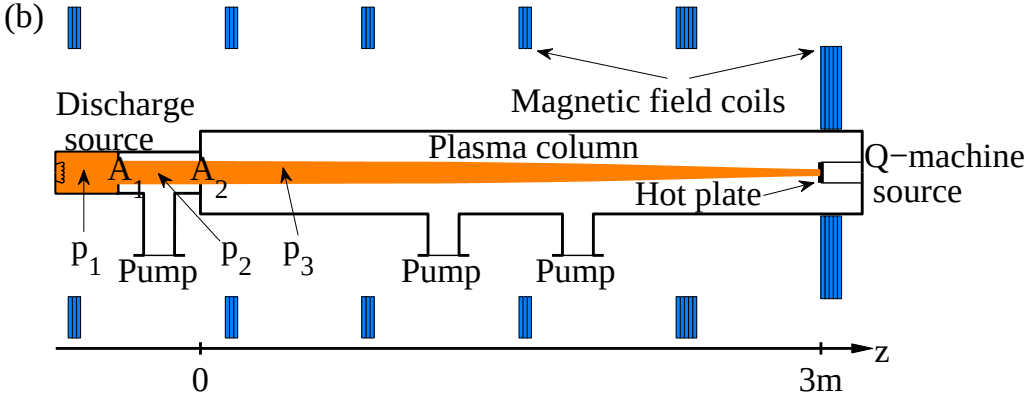
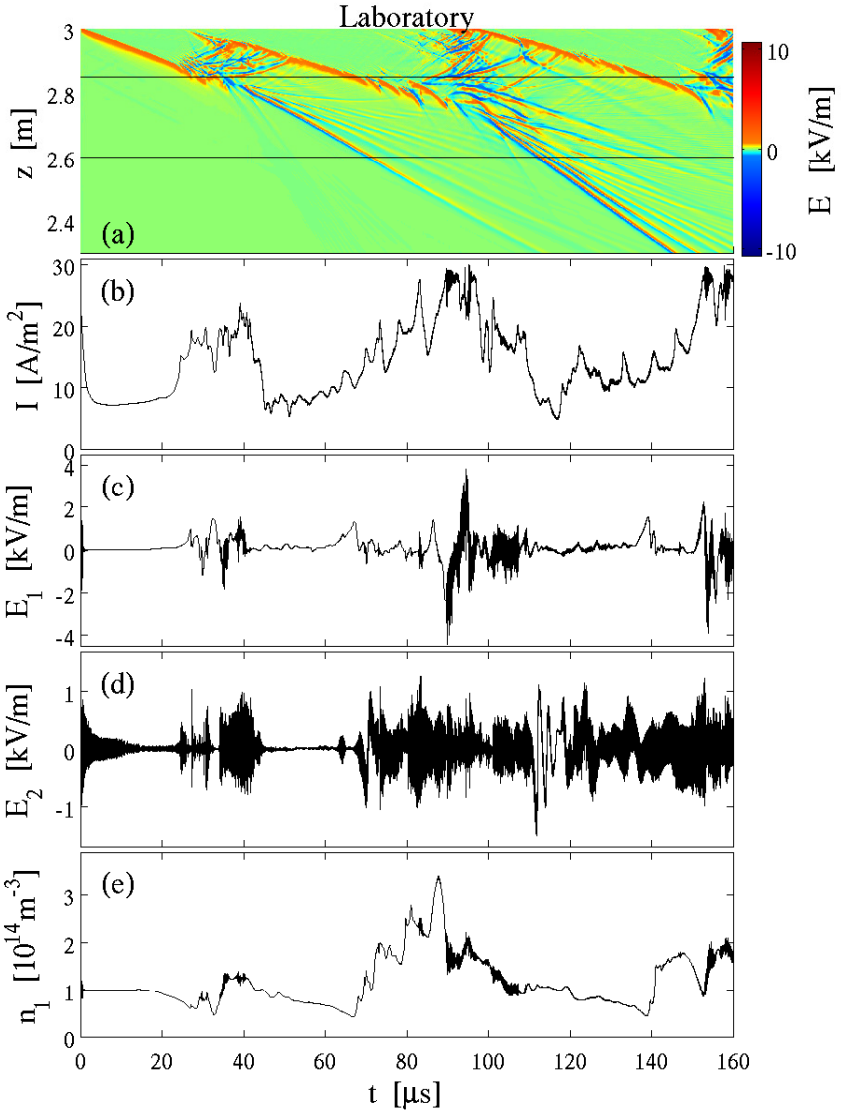


Figure from Marklund et al. (2001).

Other applications — lab (Gunell et al., 2013b, 2016)







Summary

- We have a 1d2v Vlasov simulation code.
- It has been used to simulate
  - the upward current region
  - the downward current region
  - a laboratory device intended to simulate both those regions
- In the MOMA project we shall
  - include an ionosphere modelled by Monte Carlo simulations
  - couple the upward and downward current regions
  - simulate AKR emissions

Bibliography I

Andersson, L., Ergun, R.E., Newman, D.L., McFadden, J.P., Carlsson, C.W., Su, Y.J., 2002. Formation of parallel electric fields in the downward current region of the aurora. Physics of Plasmas 9, 3600–3609. doi:10.1063/1.1490134.

Gunell, H., Andersson, L., De Keyser, J., Mann, I., 2015a. Self-consistent electrostatic simulations of reforming double layers in the downward current region of the aurora. Annales Geophysicae 33, 1331–1342. doi:10.5194/angeo-33-1331-2015.

Gunell, H., Andersson, L., De Keyser, J., Mann, I., 2015b. Vlasov simulations of trapping and loss of auroral electrons. Annales Geophysicae 33, 279–293. doi:10.5194/angeo-33-279-2015.

Gunell, H., Andersson, L., De Keyser, J., Mann, I., 2016. Can the downward current region of the aurora be simulated in the laboratory? Plasma Physics and Controlled Fusion 58, 054003. doi:10.1088/0741-3335/58/5/054003.

Gunell, H., De Keyser, J., Gamby, E., Mann, I., 2013a. Vlasov simulations of parallel potential drops. Annales Geophysicae 31, 1227–1240. doi:10.5194/angeo-31-1227-2013.

Gunell, H., De Keyser, J., Mann, I., 2013b. Numerical and laboratory simulations of auroral acceleration. Physics of Plasmas 20, 102901. doi:10.1063/1.4824453.

Marklund, G.T., Ivchenko, N., Karlsson, T., Fazakerley, A., Dunlop, M., Lindqvist, P.A., Buchert, S., Owen, C., Taylor, M., Vaivalds, A., Carter, P., André, M., Balogh, A., 2001. Temporal evolution of the electric field accelerating electrons away from the auroral ionosphere. Nature 414, 724–727. doi:10.1038/414724a.