Energetic ion depletions near Europa and Io: the effect of plumes and atmospheric charge exchange

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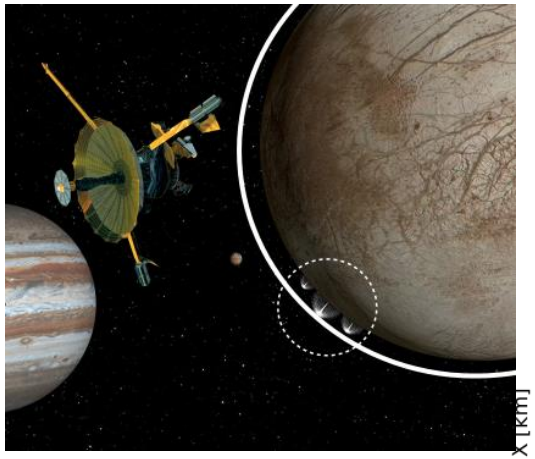
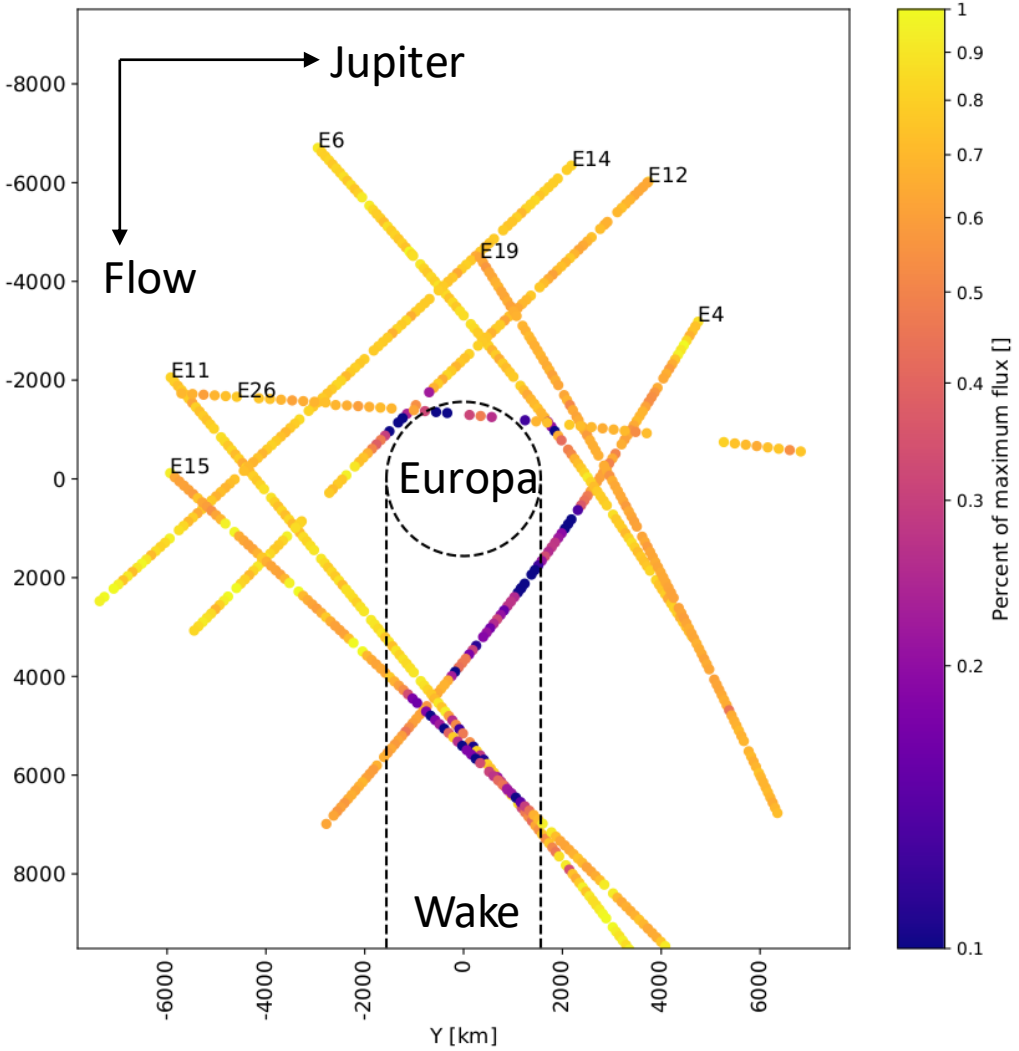
Introduction

- Depletions of the energetic ions (protons, oxygen, sulphur), of several orders of magnitude, were identified near Galilean moons (e.g. Io and Europa)
- Possible causes:
  - absorption of these particles onto the moon's surfaces
  - loss due to charge exchange with neutral molecules in the atmospheres or potential plumes.
  - gradients in EM field

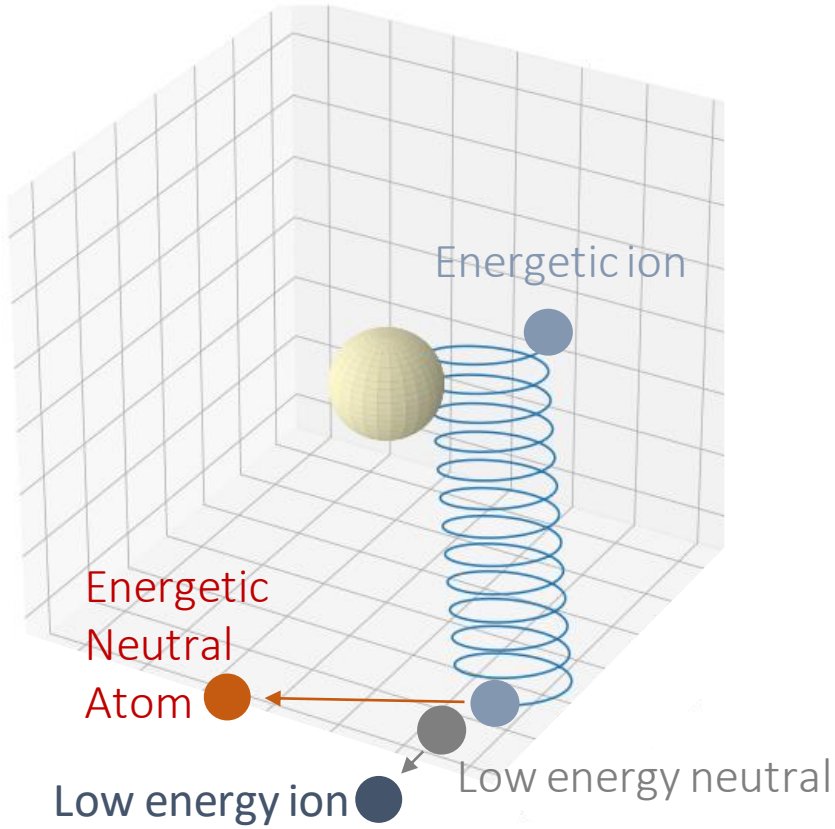


H^+ depletions (220 to 550 keV) near Europa (Galileo EPD data)



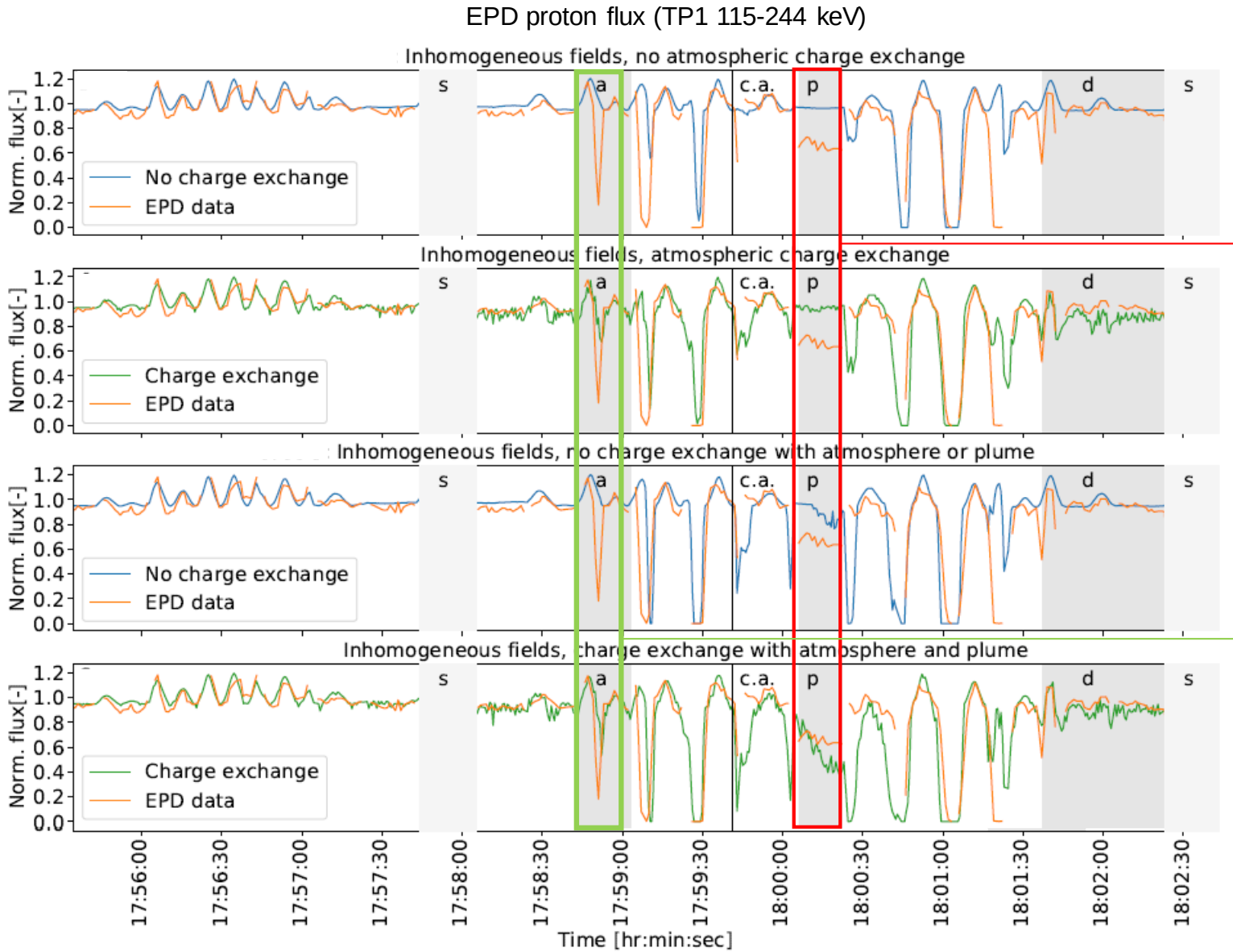
Method

- Monte Carlo particle tracing *
- Simulating ion trajectories and flux under different scenarios (with/without charge exchange).
- By comparing the simulated flux to the data the cause of the depletion features can be investigated.



* Huybrighs et al., 2017, Icarus https://doi.org/10.1016/j.icarus.2016.10.026

Europa flyby E26: plume signature & charge exchange



No plume

With plume

Key result 1

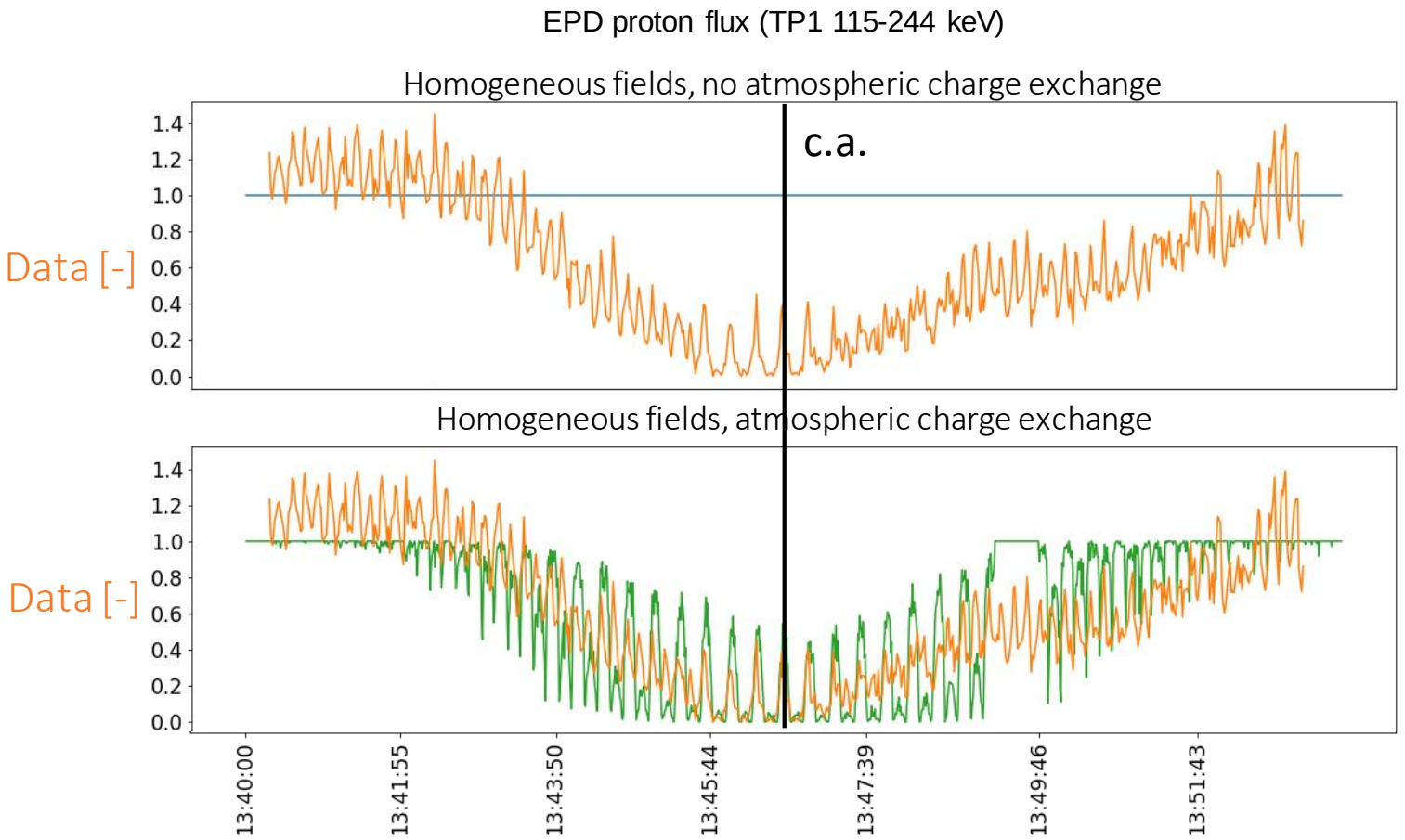
Plume signature ('p') depletion only reproduced when plume is included.

Key result 2

Atmospheric charge exchange needed to explain some depletions (e.g. 'a')

[Huybrighs et al,. 2020, GRL, https://doi.org/10.1029/2020GL087806]

Io flyby I27: charge exchange & fields



Simulation
no charge exchange

Simulation charge exchange with atmosphere
Surf. density = 10^9 cm^{-3}
Scale height = 100 km
Cross section: O_2

- Depletion extending beyond one Io radius
- Charge exchange required to explain depletions
- Effect of inhomogeneous fields under investigation *

* Ongoing MSc thesis project by Christiaan Van Buchem (ESTEC/University of Leiden) vbuchem@strw.leidenuniv.nl

Conclusion

- Europa flyby E26
  - **We conclude, with a new method and independent dataset, that Galileo could have encountered a plume during E26.**
  - Energetic proton flux depletions during E26 are reproduced by taking into account: inhomogeneous **fields**, atmospheric **charge exchange** and a **plume**
  - Plumes can deplete protons through charge exchange and field perturbations
- Io flyby I27
  - Ions depleted over region extending beyond one Io radius
  - Under homogeneous EM field **charge exchange** is required to explain depletion
  - Effect of inhomogeneous fields should be investigated

More information?

- I’m happy to discuss this work further (e.g. on skype)
- Contact me: hans.huybrighs@esa.int
- Huybrighs, H.L.F., Roussos, E., Blocker, A., Krupp, N., Futaana, Y., Barabash, S., Hadid, L.Z., Holmberg, M.K.G., Lomax, O., and Witasse, O. (2020) An active plume eruption on Europa during Galileo flyby E26 as indicated by energetic proton depletions. *Geophysical Research Letters*. *https://doi.org/10.1029/2020GL087806*

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