SMILEI Workshop, Saclay, Monday, November 6th

Astrophysical plasma applications of SMILEI

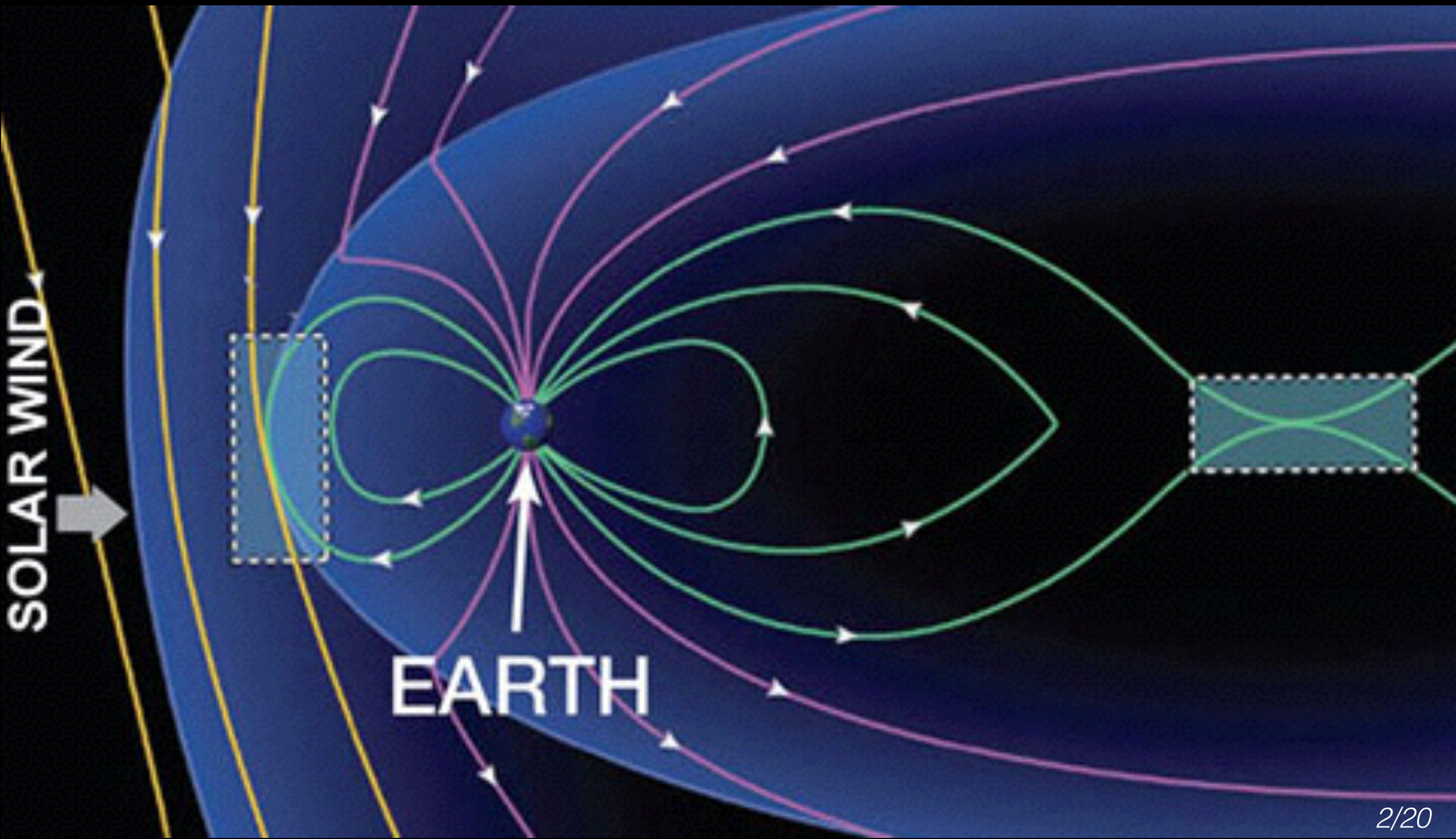
Magnetic reconnection at the Earth's magnetopause

Jérémy Dargent,

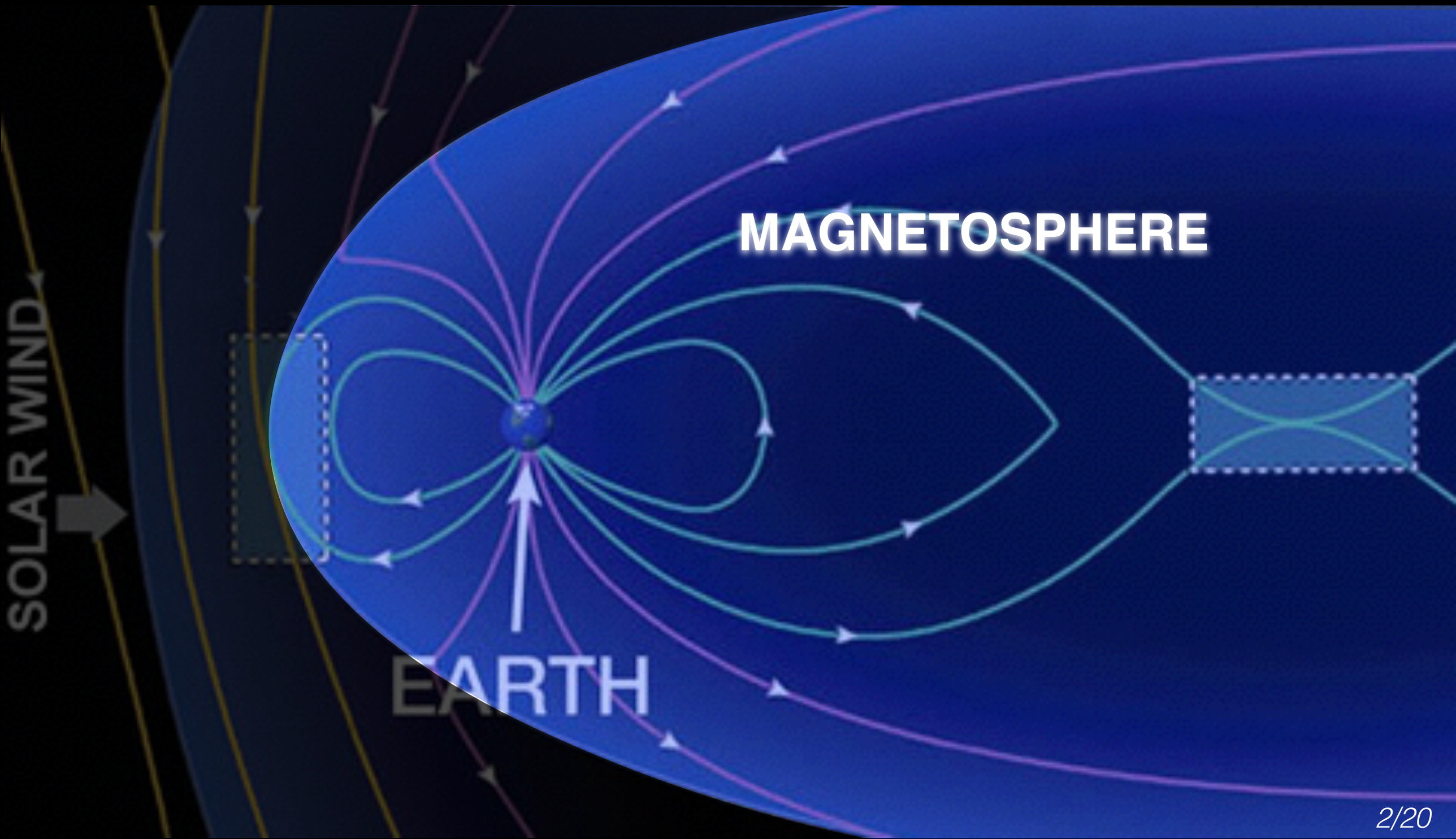
Nicolas Aunai, Benoît Lavraud & Sergio Toledo-Redondo

Laboratory of Plasma Physics
Palaiseau, France
&
IRAP
Toulouse, France

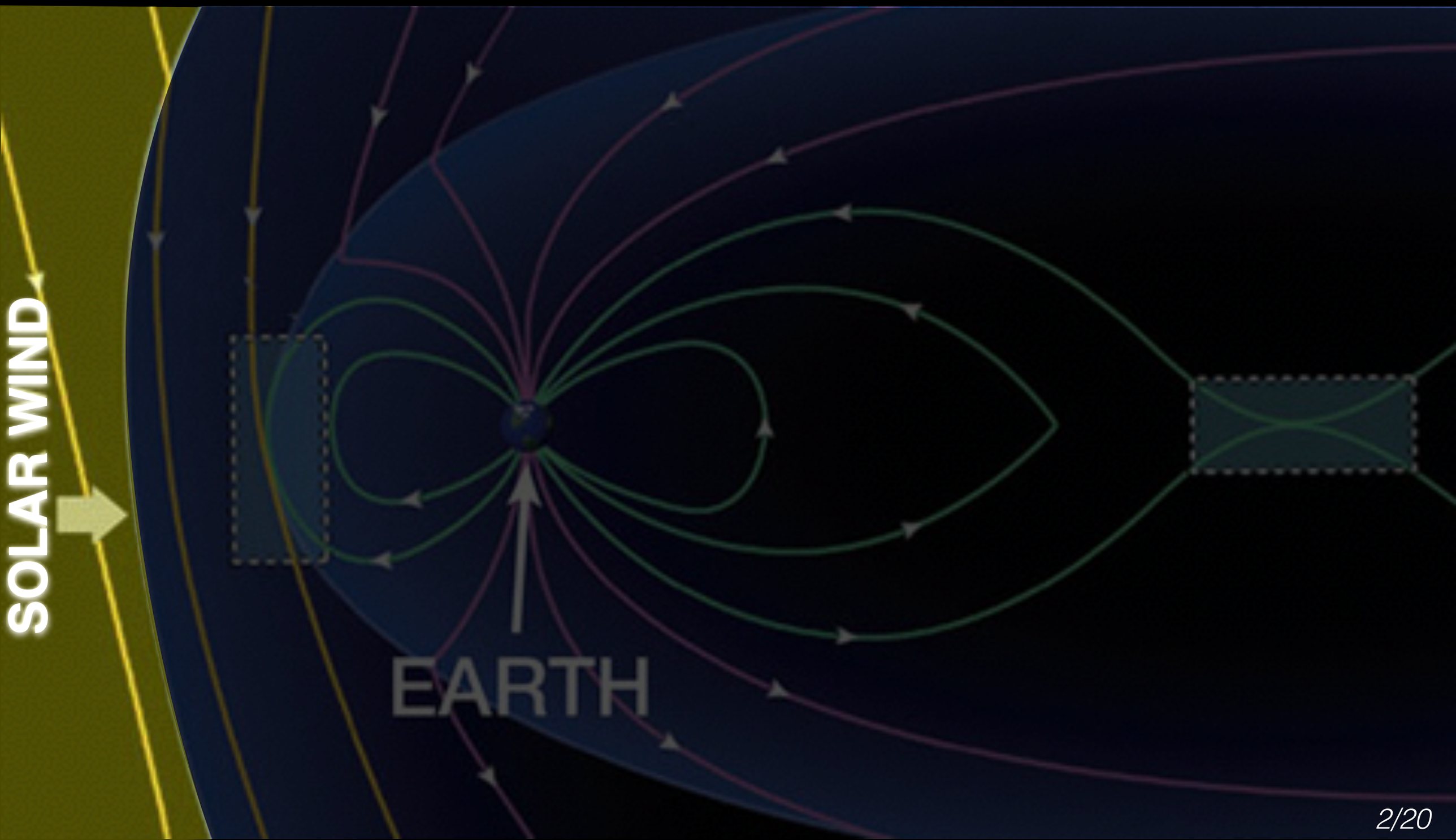
The Earth’s magnetosphere



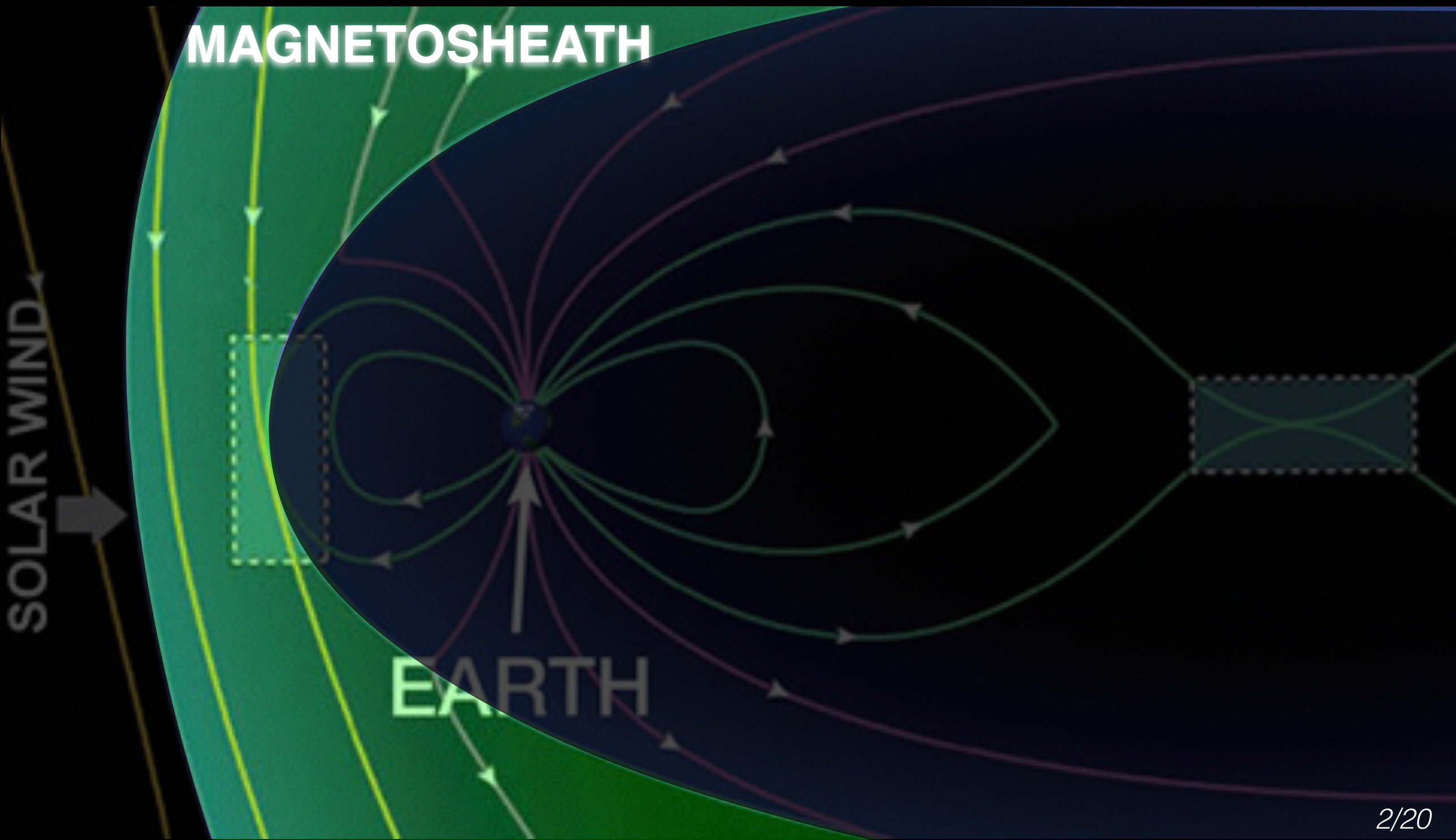
The Earth's magnetosphere



The Earth’s magnetosphere

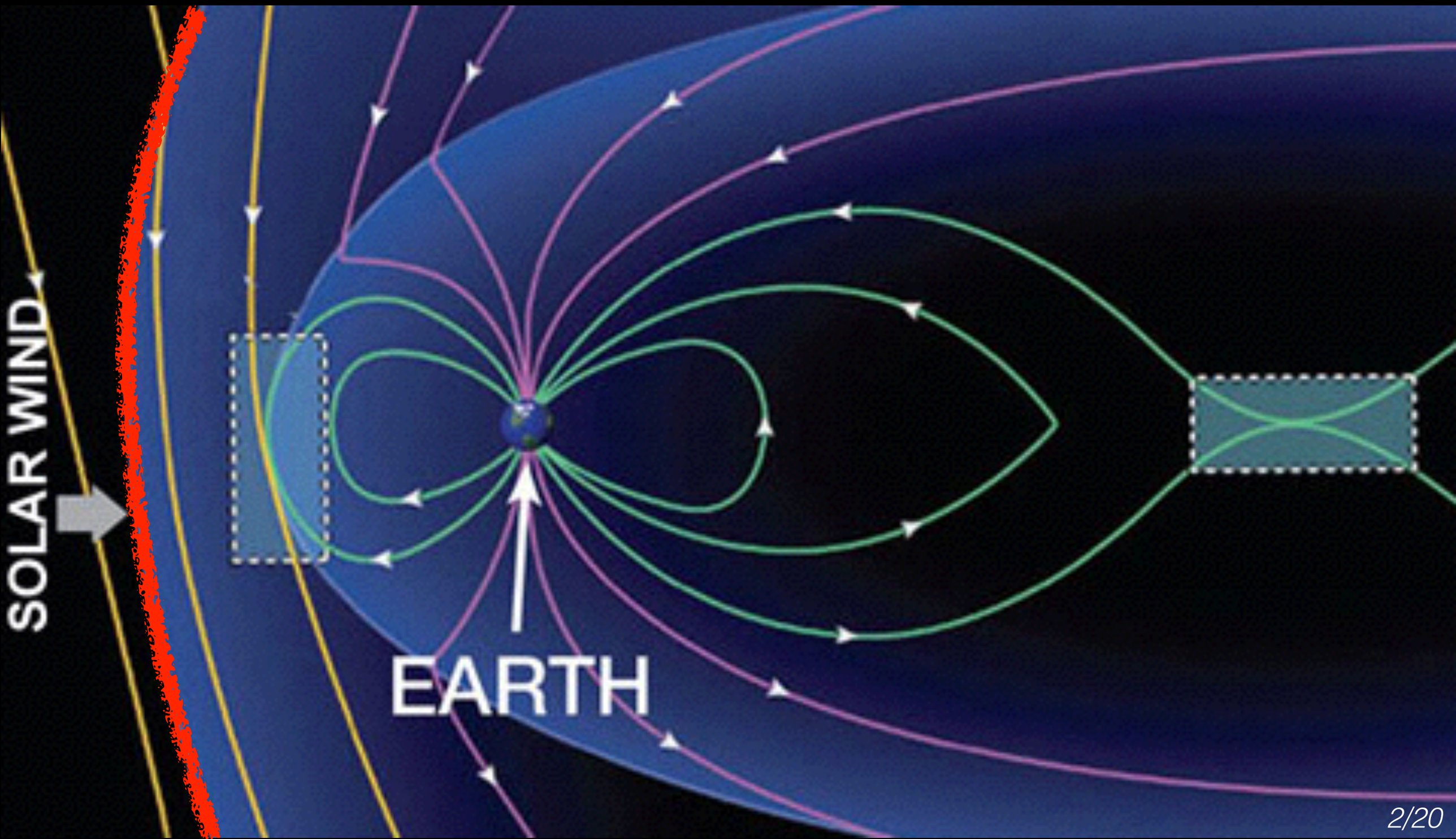


The Earth's magnetosphere



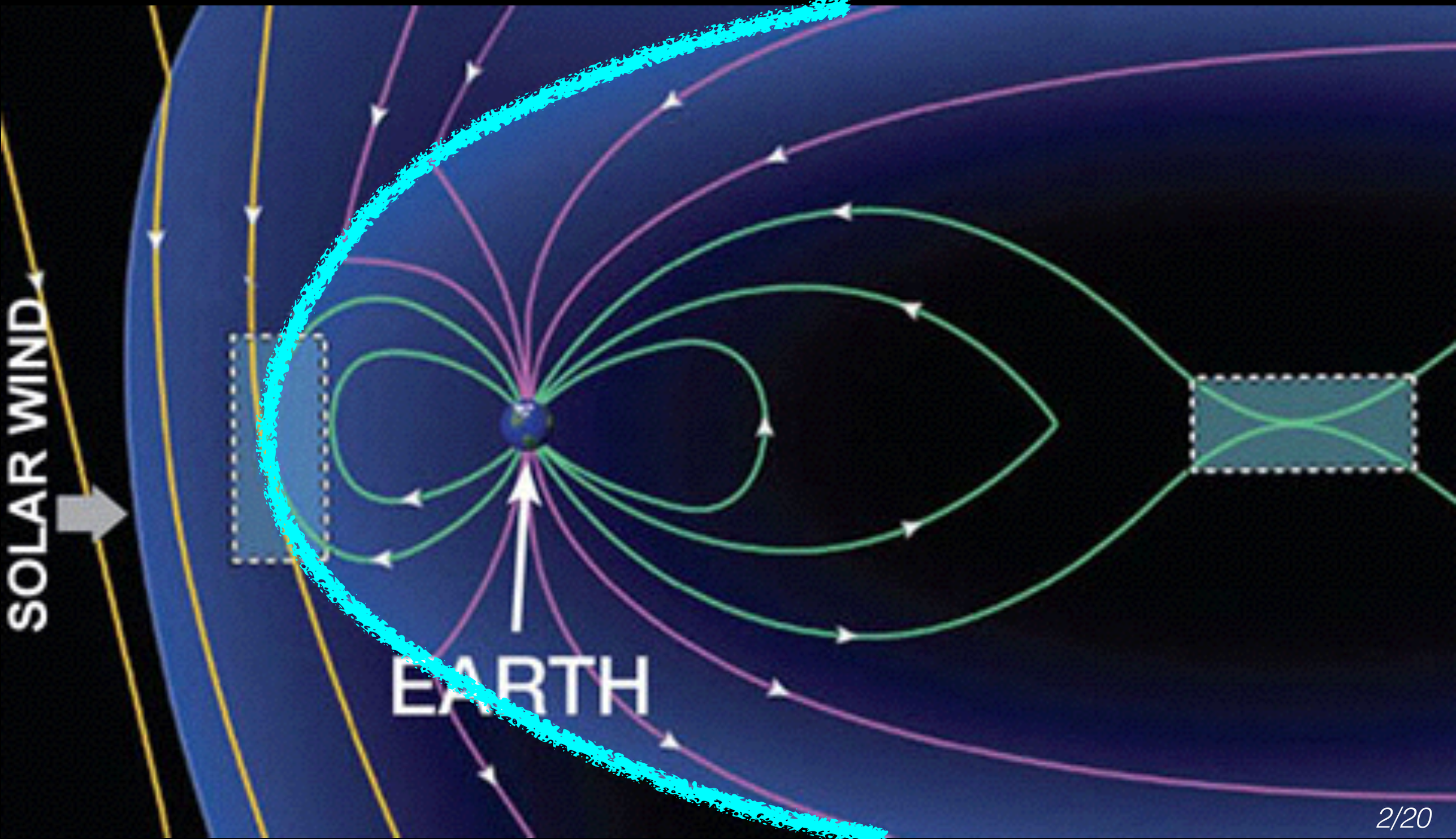
The Earth's magnetosphere

Bow shock



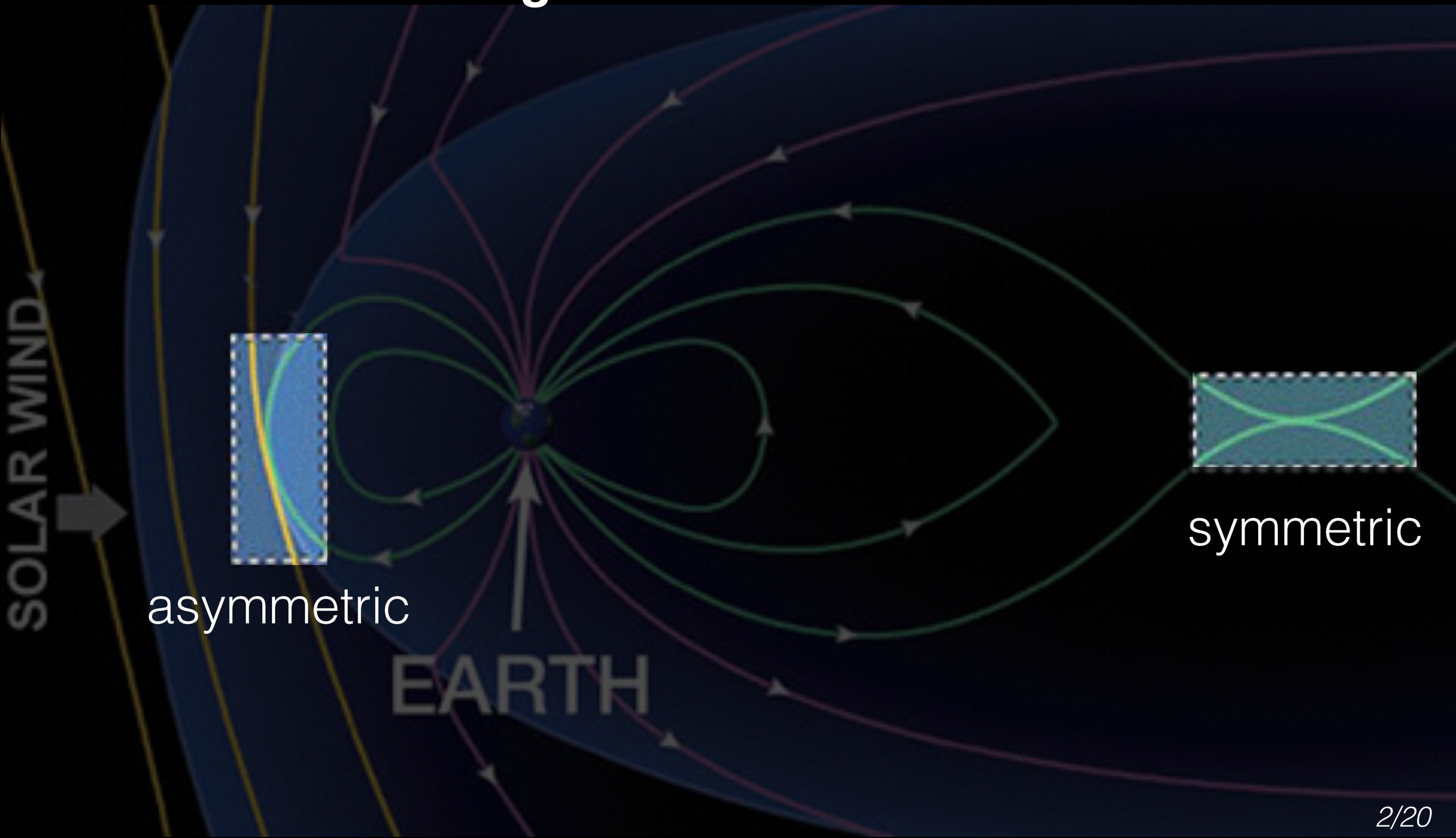
The Earth's magnetosphere

Magnetopause



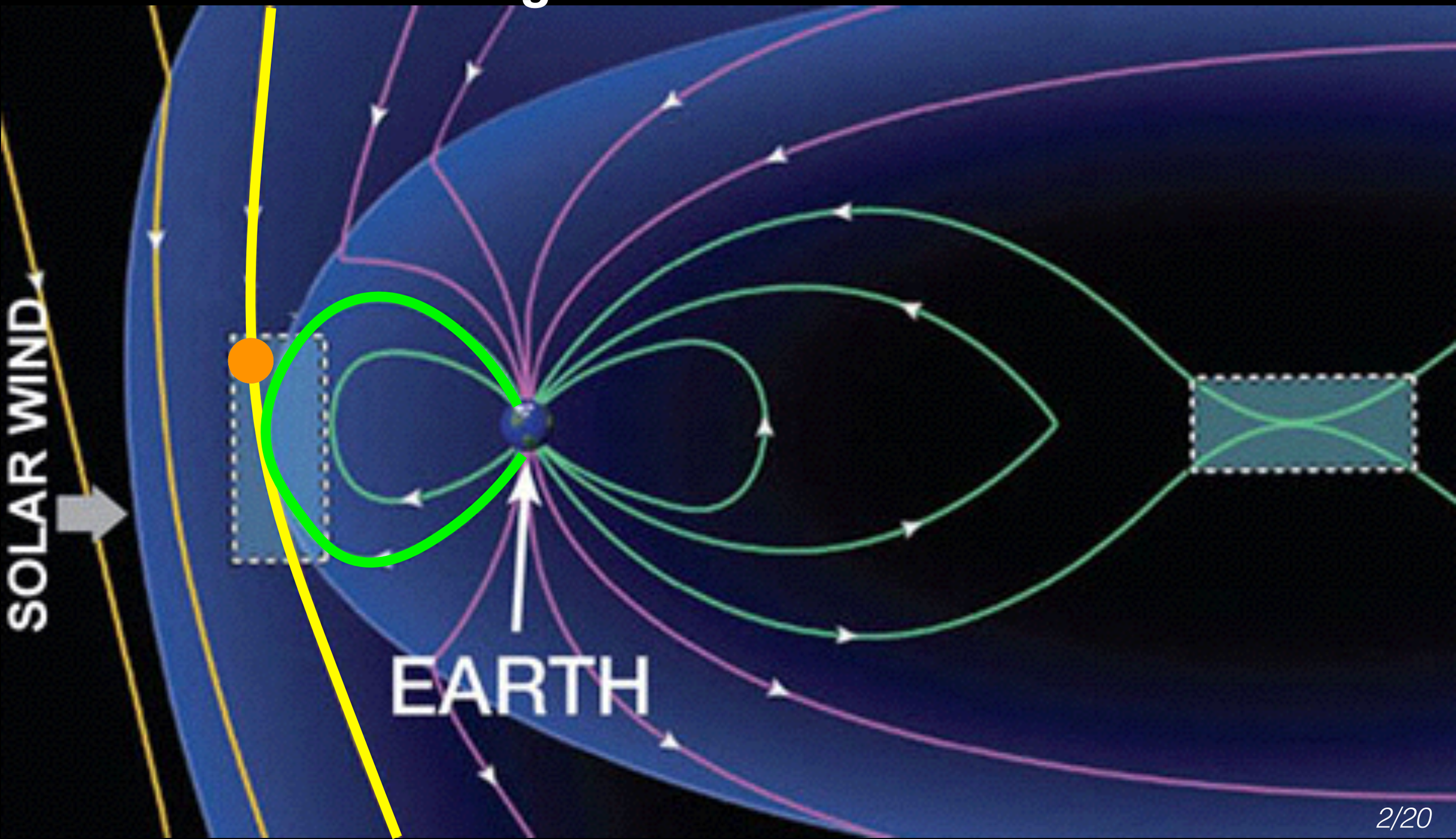
The Earth’s magnetosphere

Magnetic reconnection



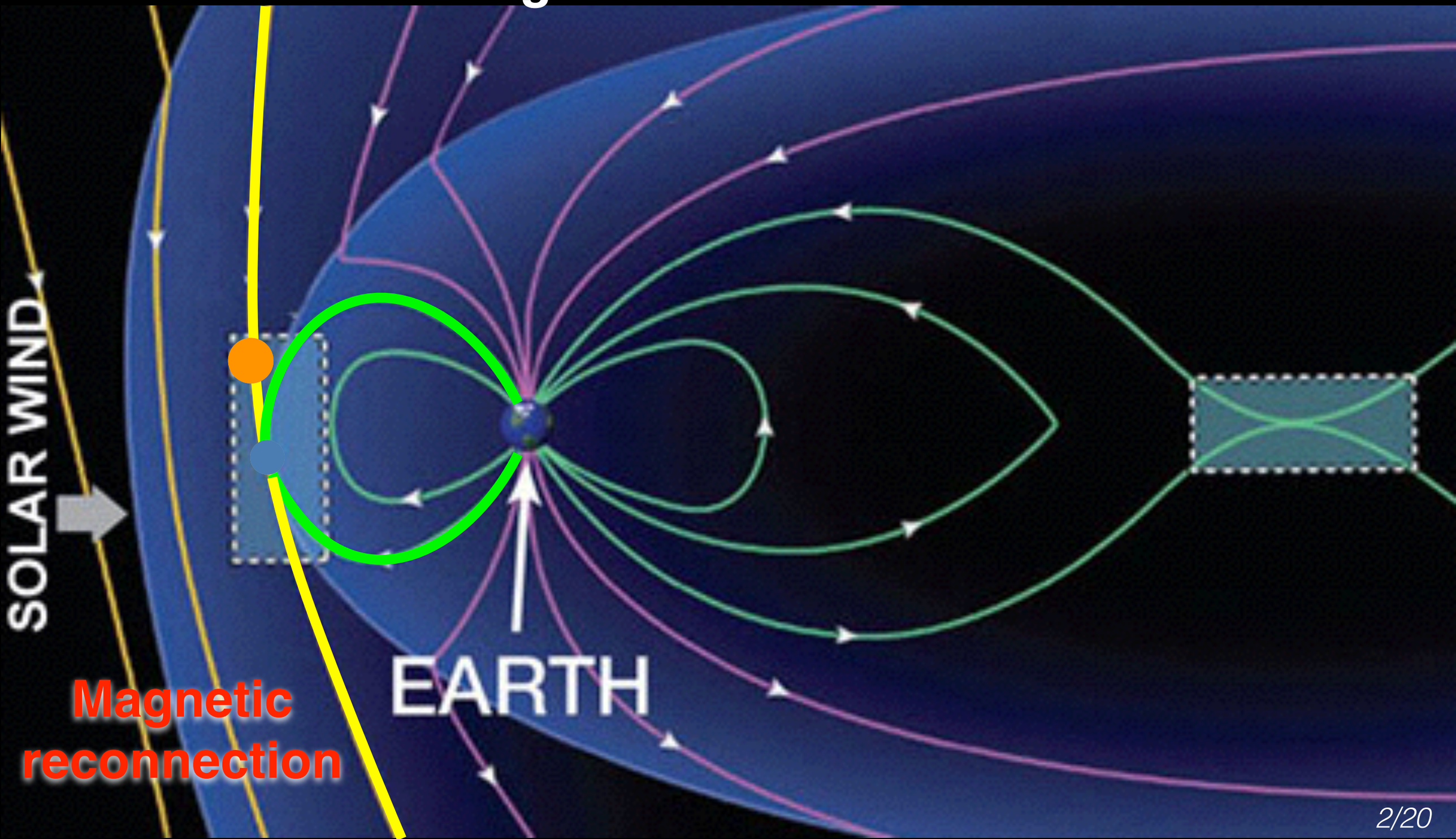
The Earth's magnetosphere

Magnetic reconnection



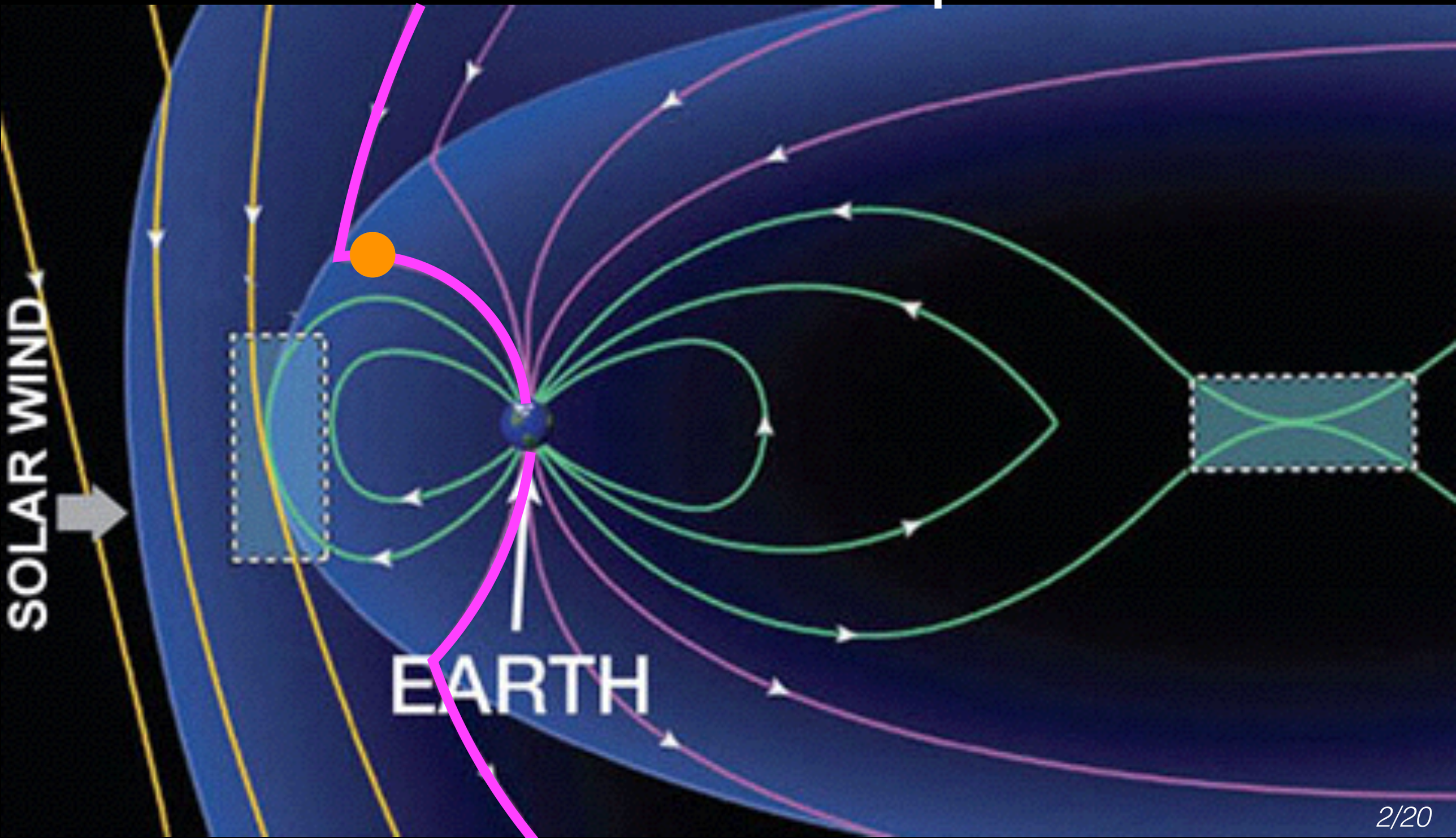
The Earth's magnetosphere

Magnetic reconnection



The Earth's magnetosphere

Penetration of solar wind plasma

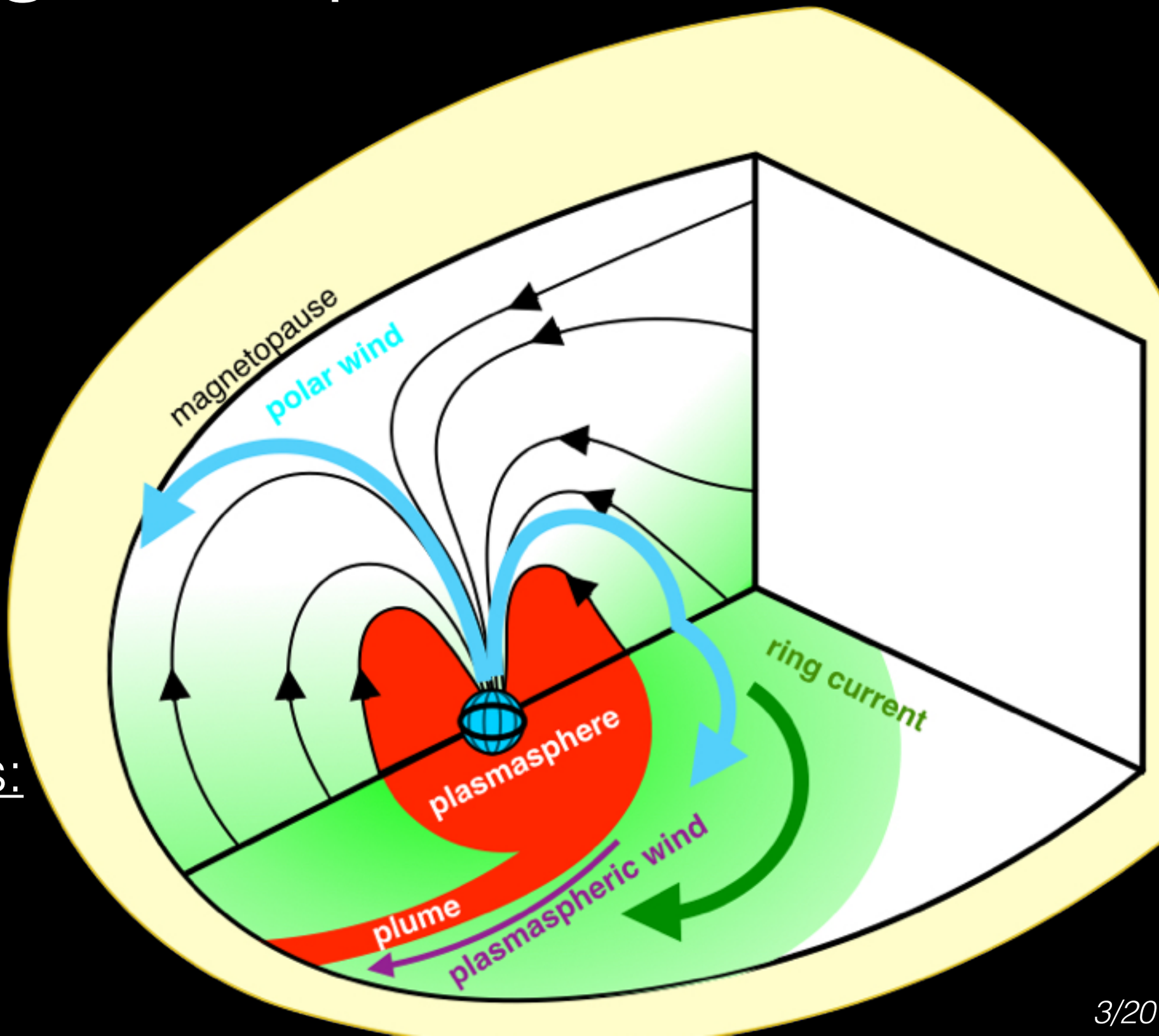


The magnetospheric cold ions

ring current:
3-100 keV
~0.2 cm^{-3}

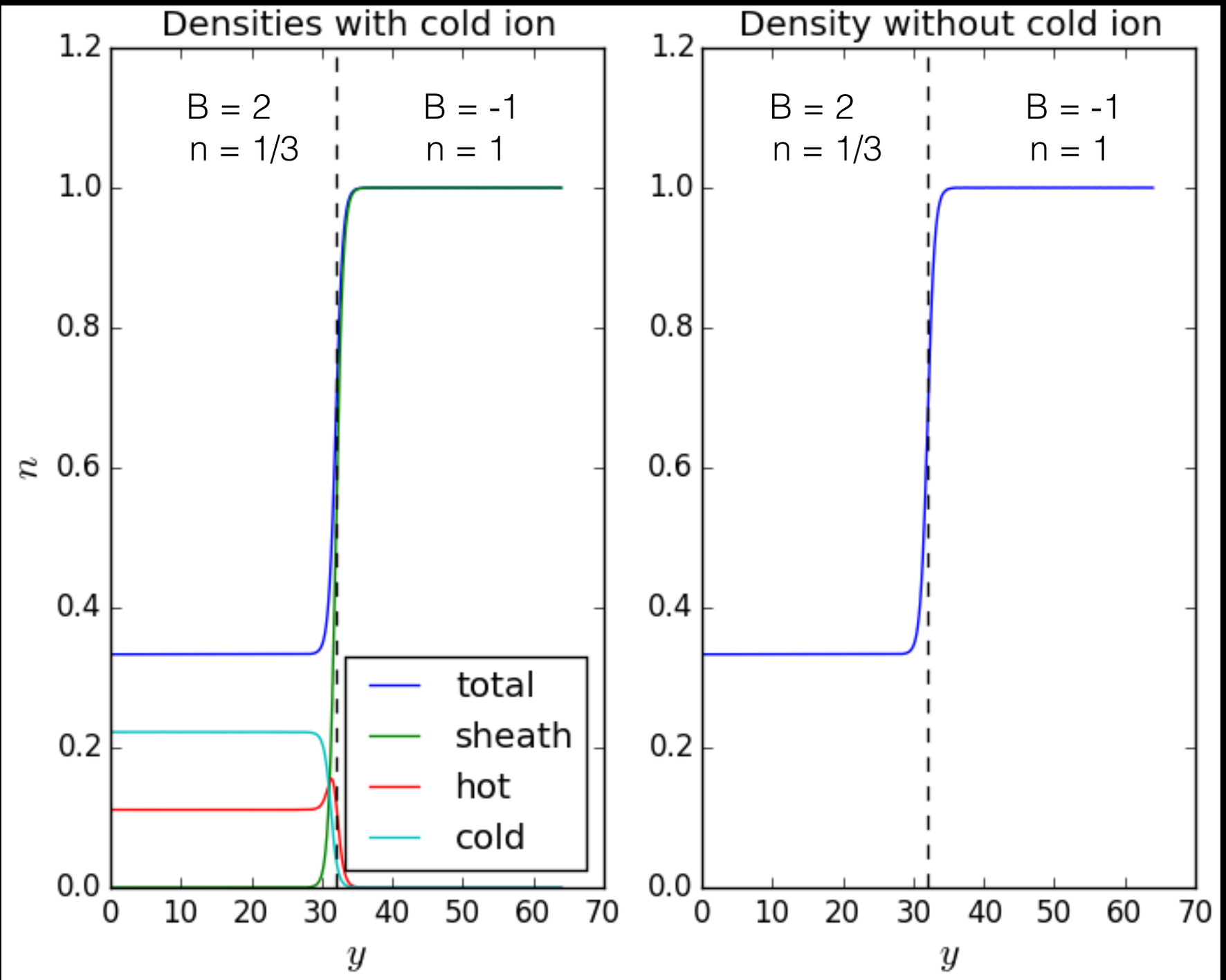
polar wind:
10 eV - 3 keV
0.05 - 3 cm^{-3}

plasmaspheric wind and plumes:
<1 eV
0.5 - 3 cm^{-3} /
3 - 40 cm^{-3}



Simulations

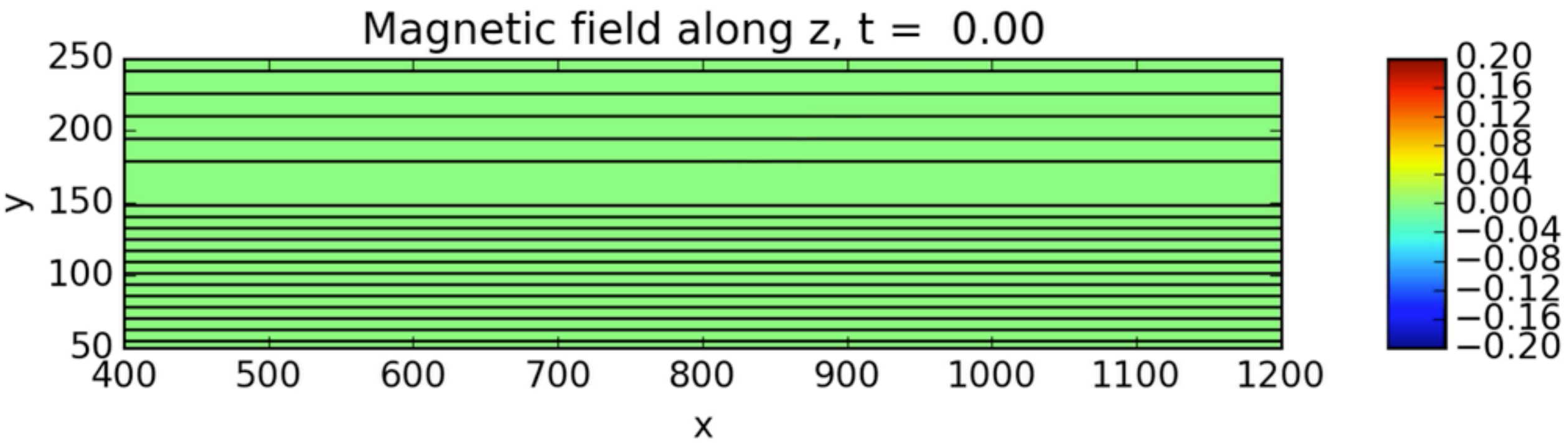
Initialization & Characteristics



- 2D simulations
- <u>Box size:</u>
  6400 * 5120 cells
- <u>Boundary condition:</u>
  Double periodic
- <u>Computing center and machine:</u>
  ADA at TGCC

Simulations

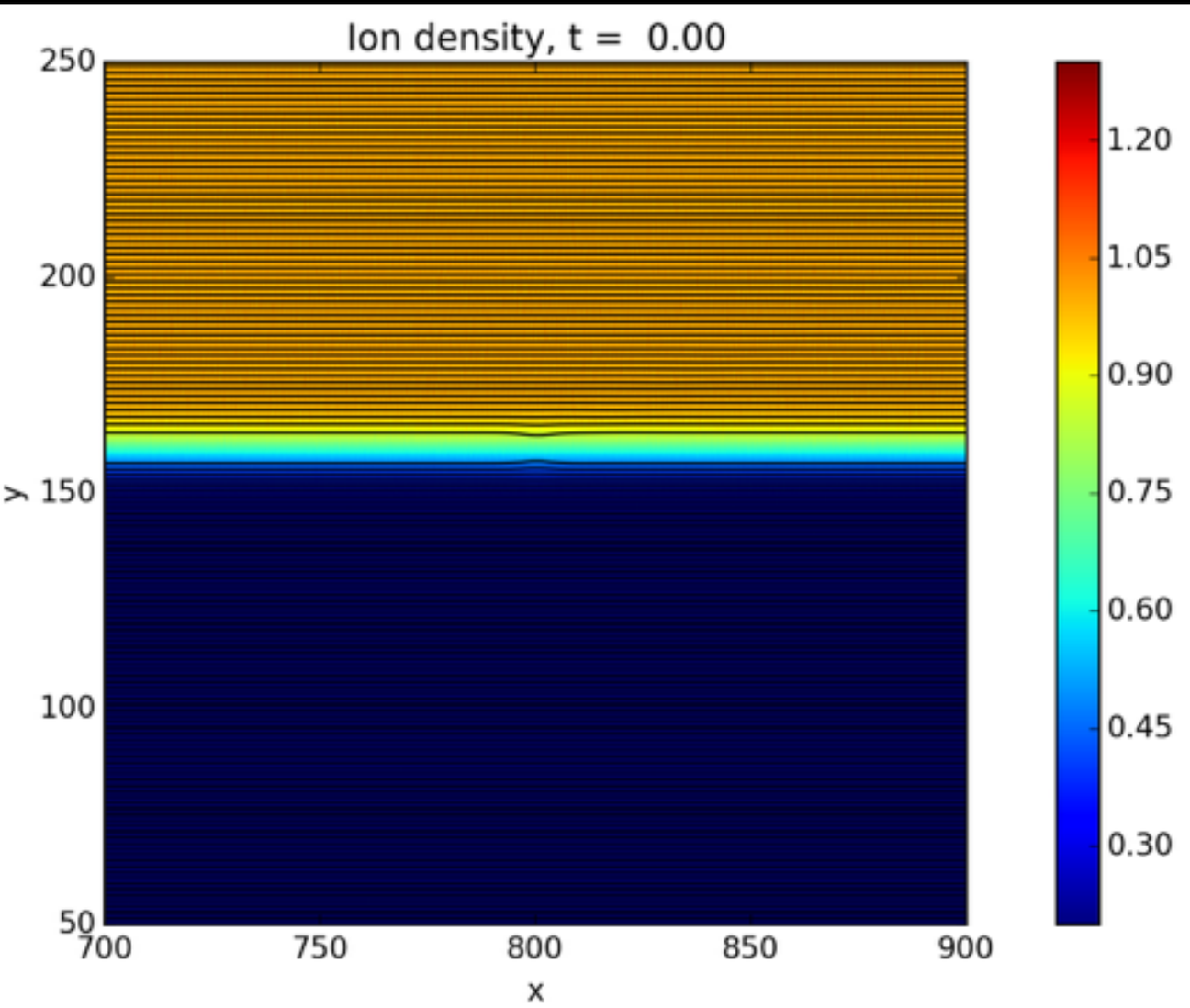
Without cold ions

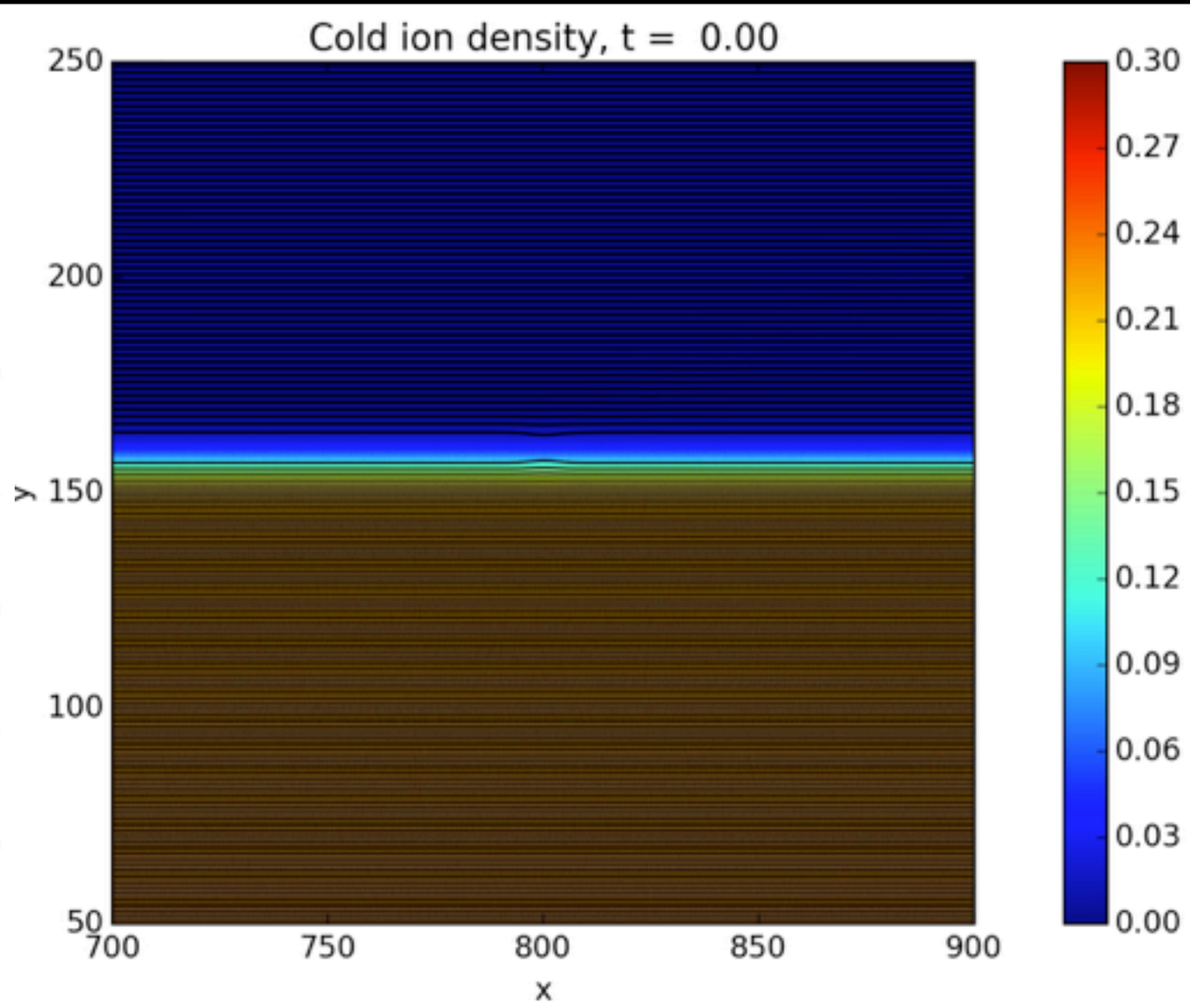


- Domain decomposition: 512 cores (4*16 MPI process / 8 OpenMP threads)
- ~ 120 000 CPU hours
- Data: ~ 5 To

Simulations

With cold ions

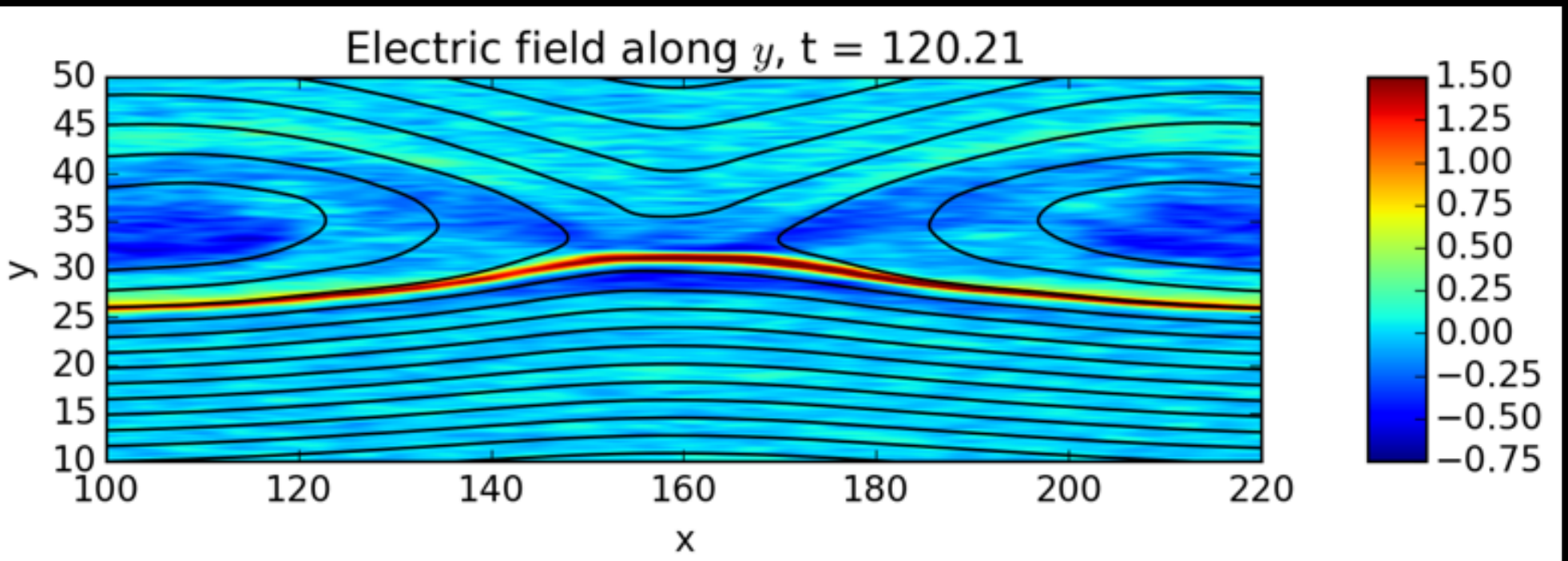




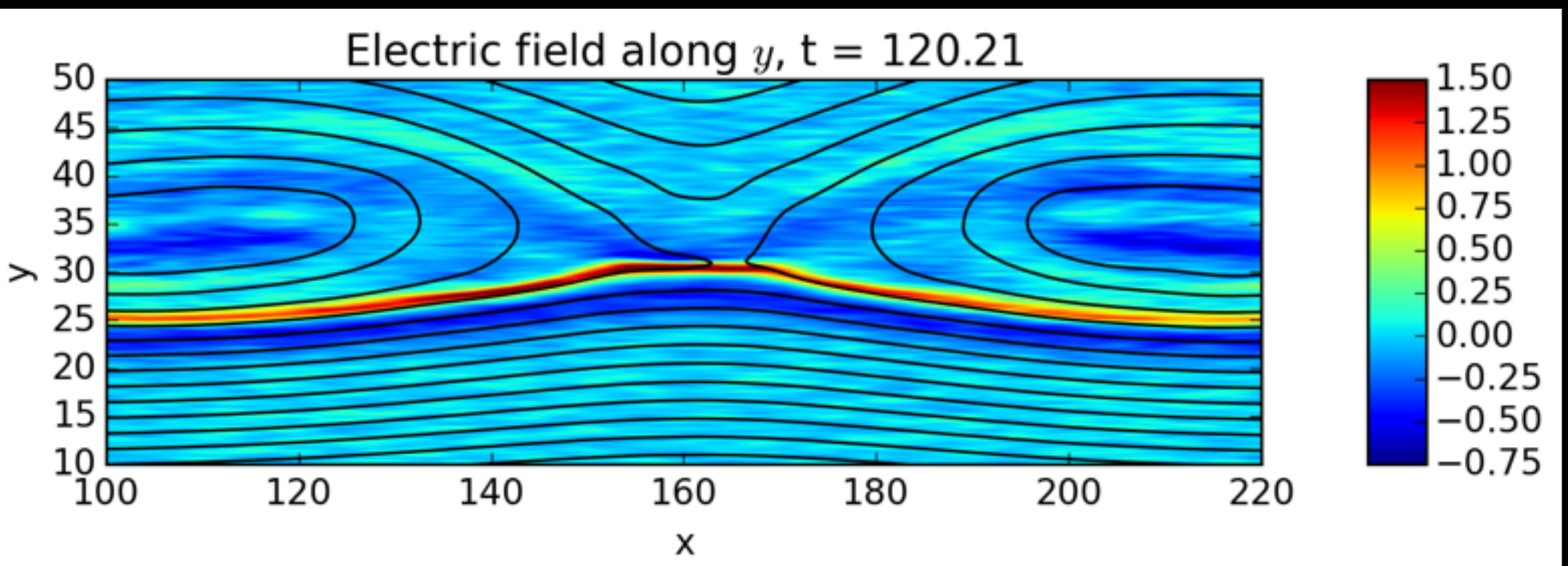
- Domain decomposition: 2048 cores (16*16 MPI process / 8 OpenMP threads)
- ~ 200 000 CPU hours
- Data: ~ 9 To

Extended electric field

Dargent et al. (2017), JGR



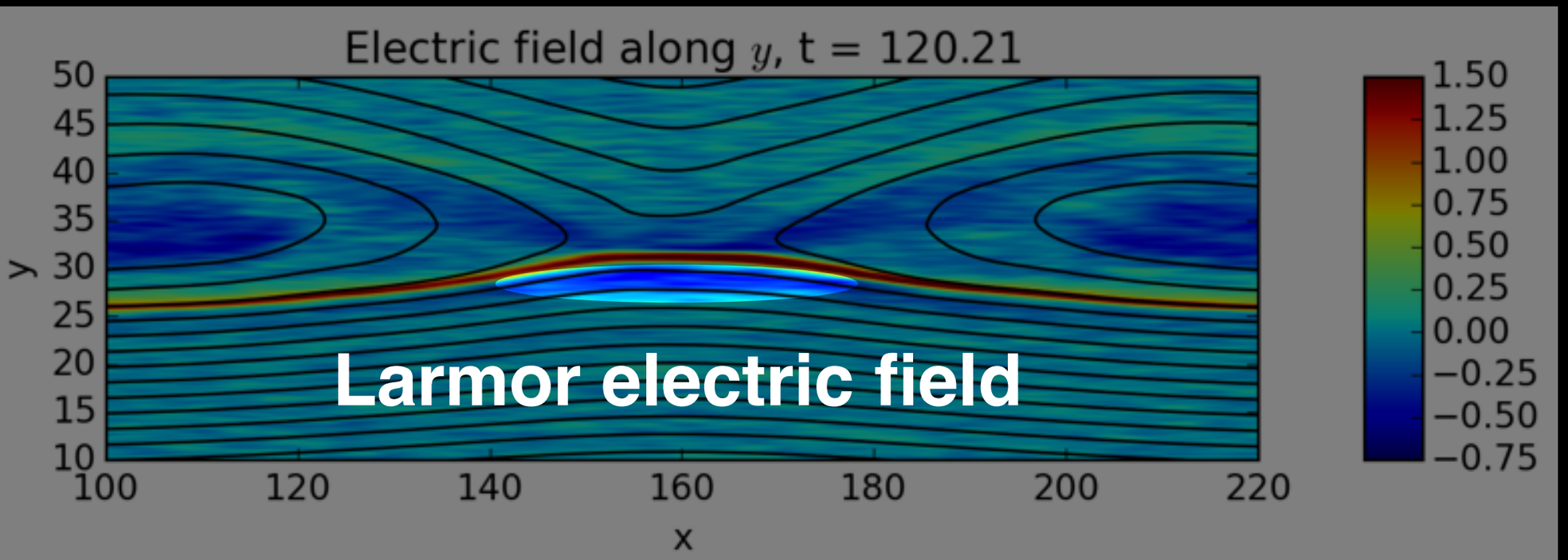
without cold ions



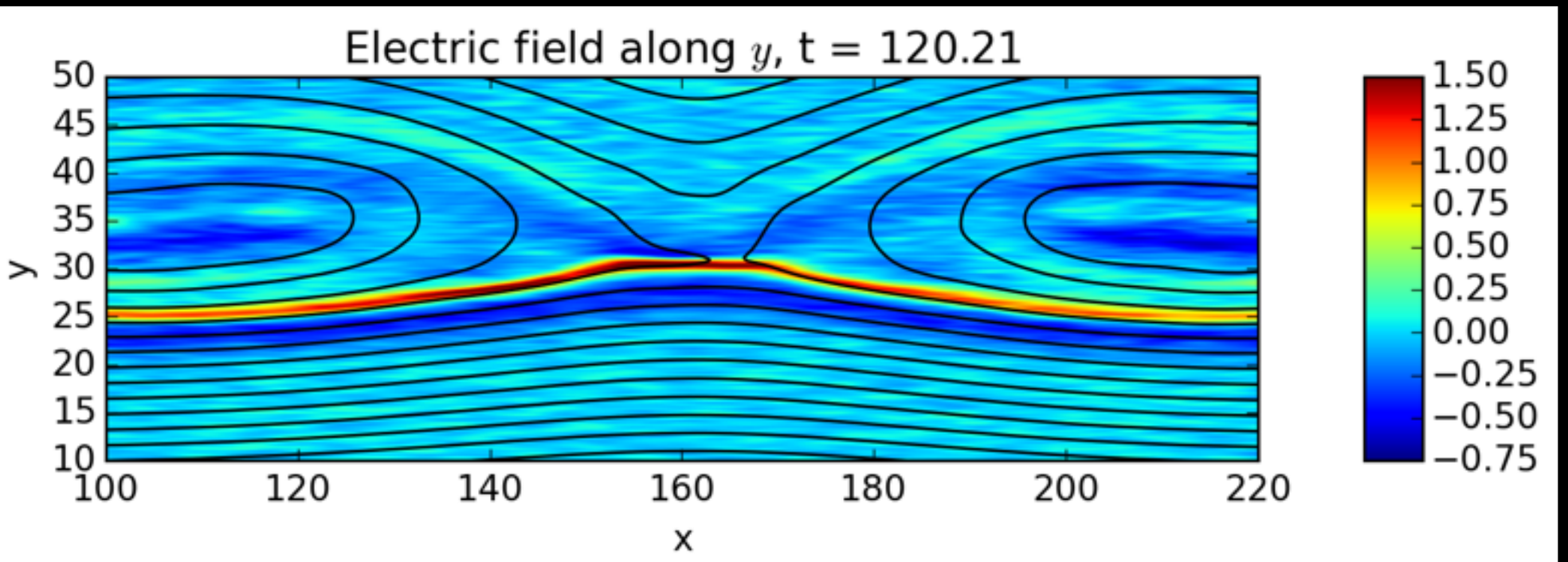
with cold ions

Extended electric field

Dargent et al. (2017), JGR



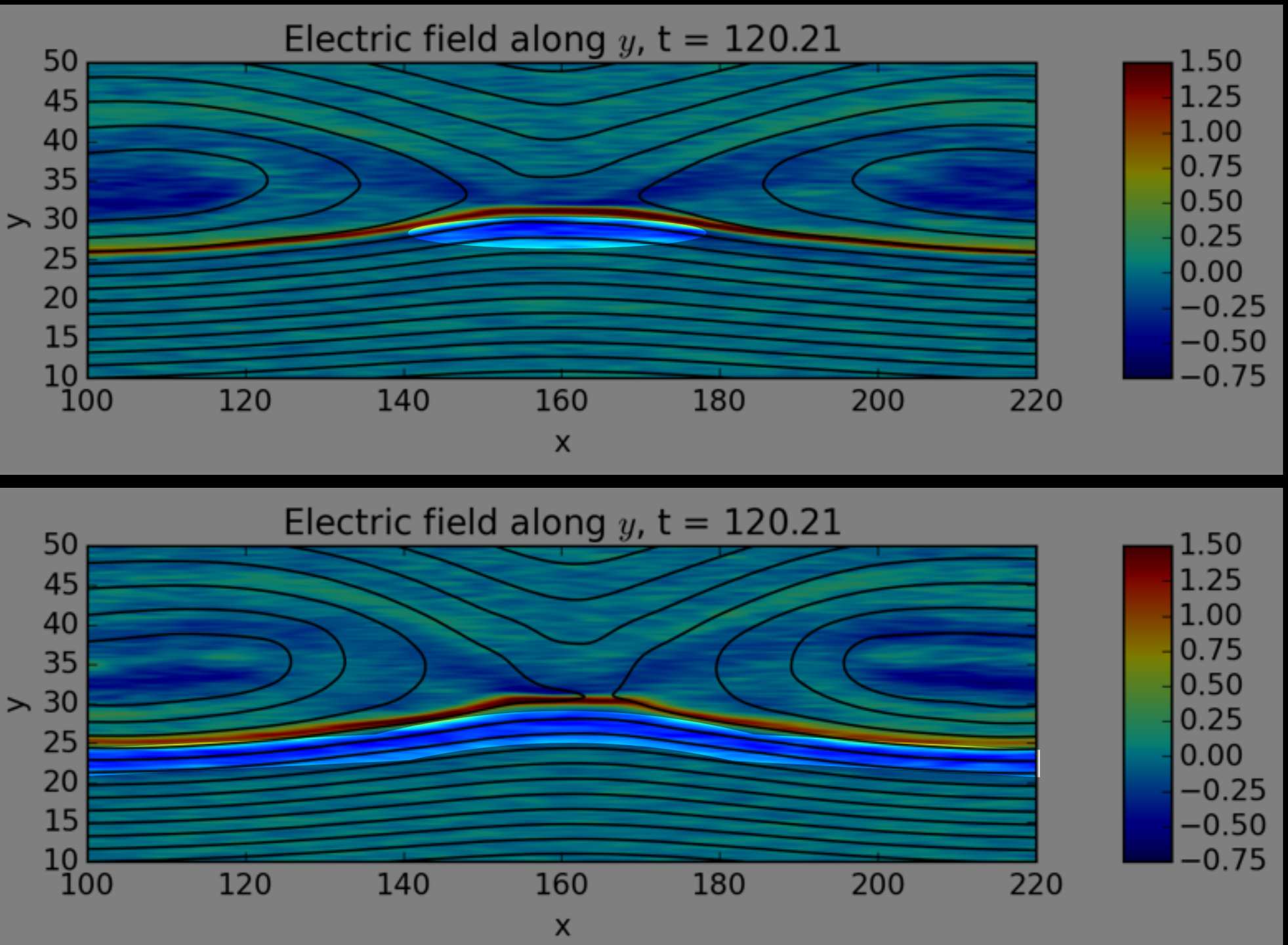
without cold ions



with cold ions

Extended electric field

Dargent et al. (2017), JGR

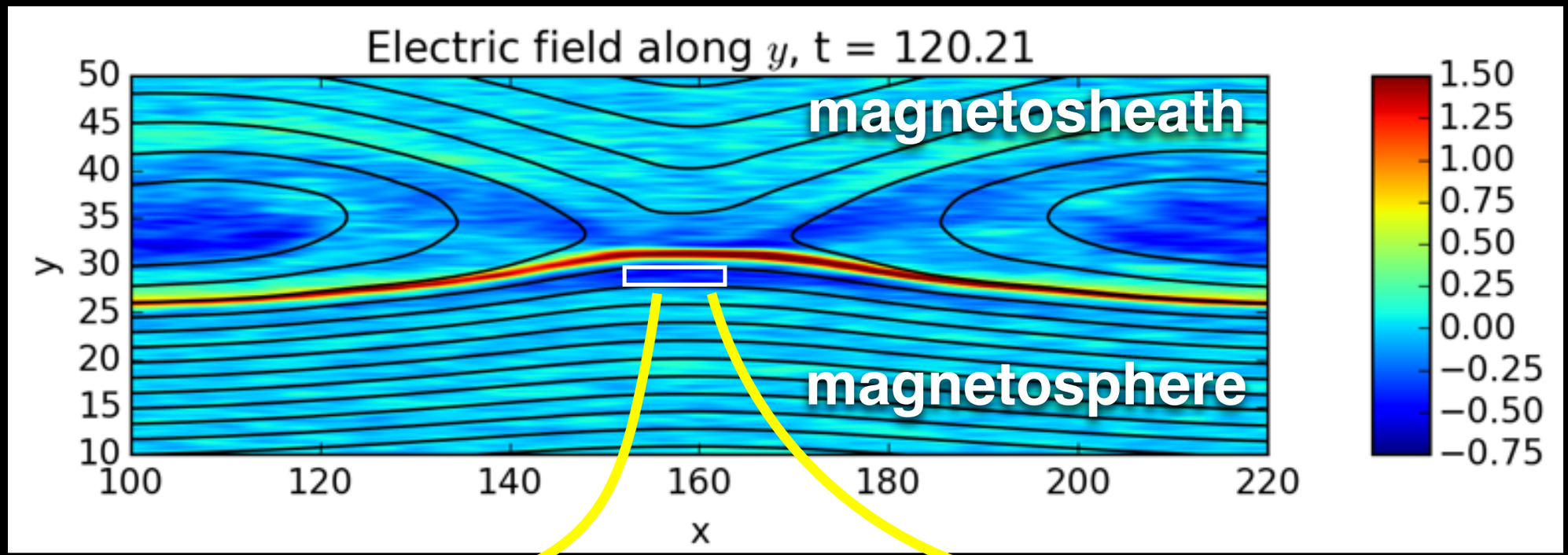


without cold ions

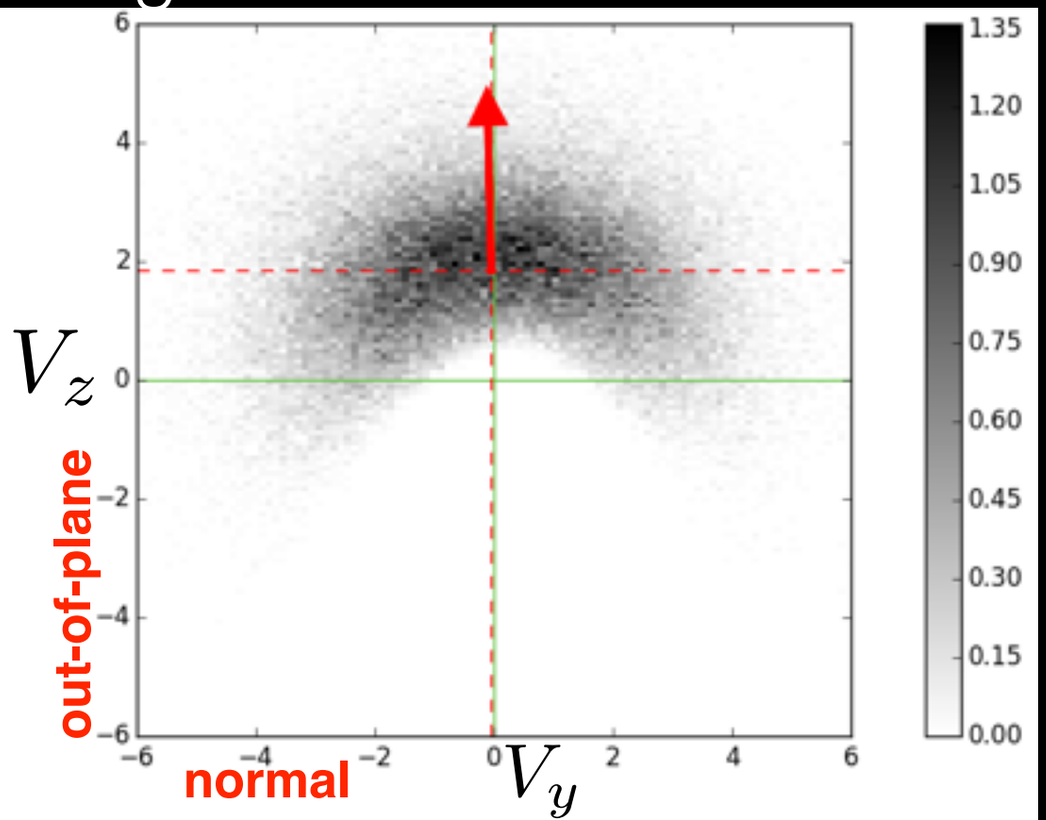
with cold ions

Tips & Tricks

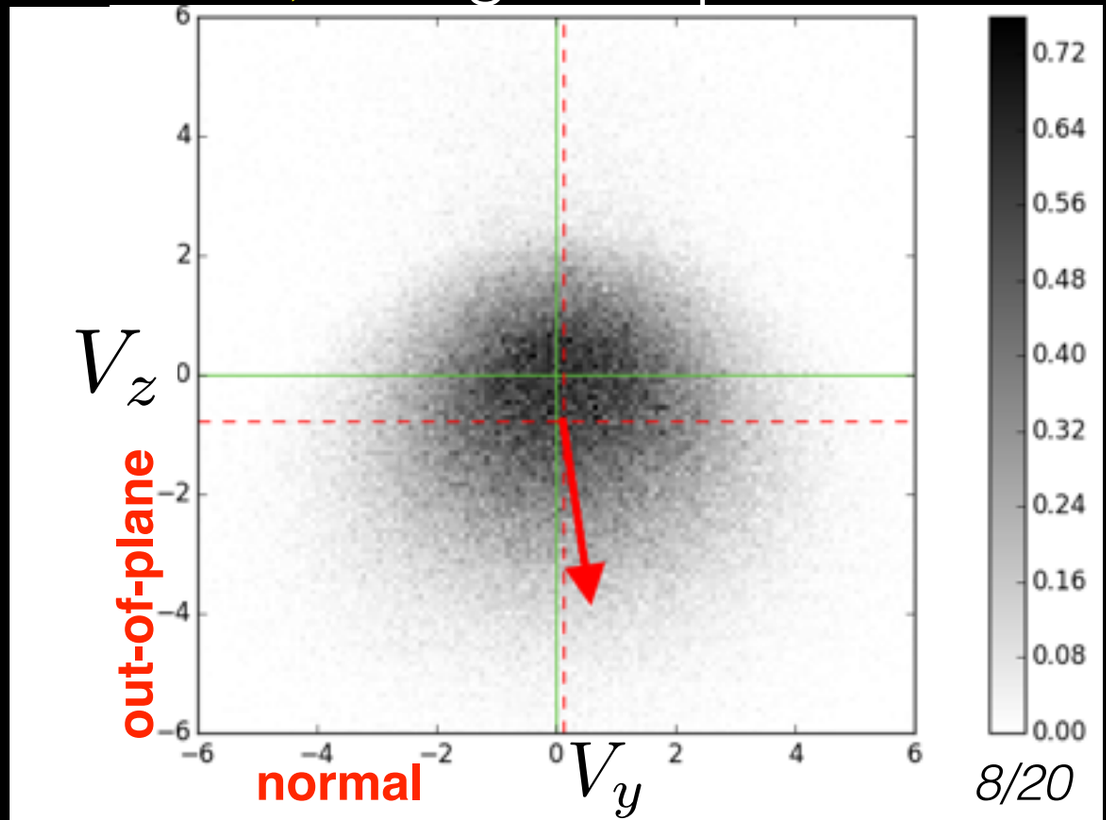
Statistical weight of particles can be used to discriminate populations



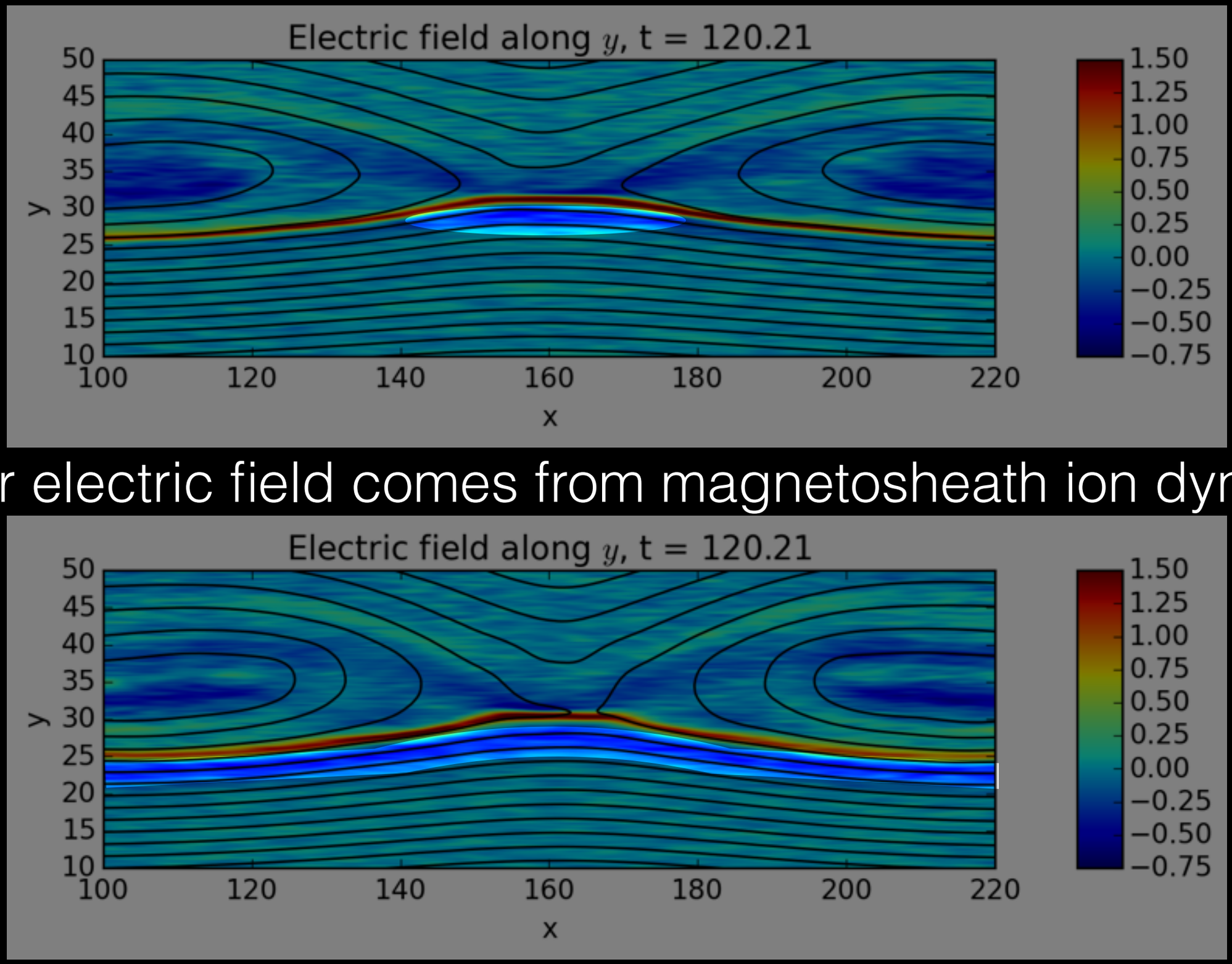
magnetosheath ions



magnetosphere ions



Results from simulation

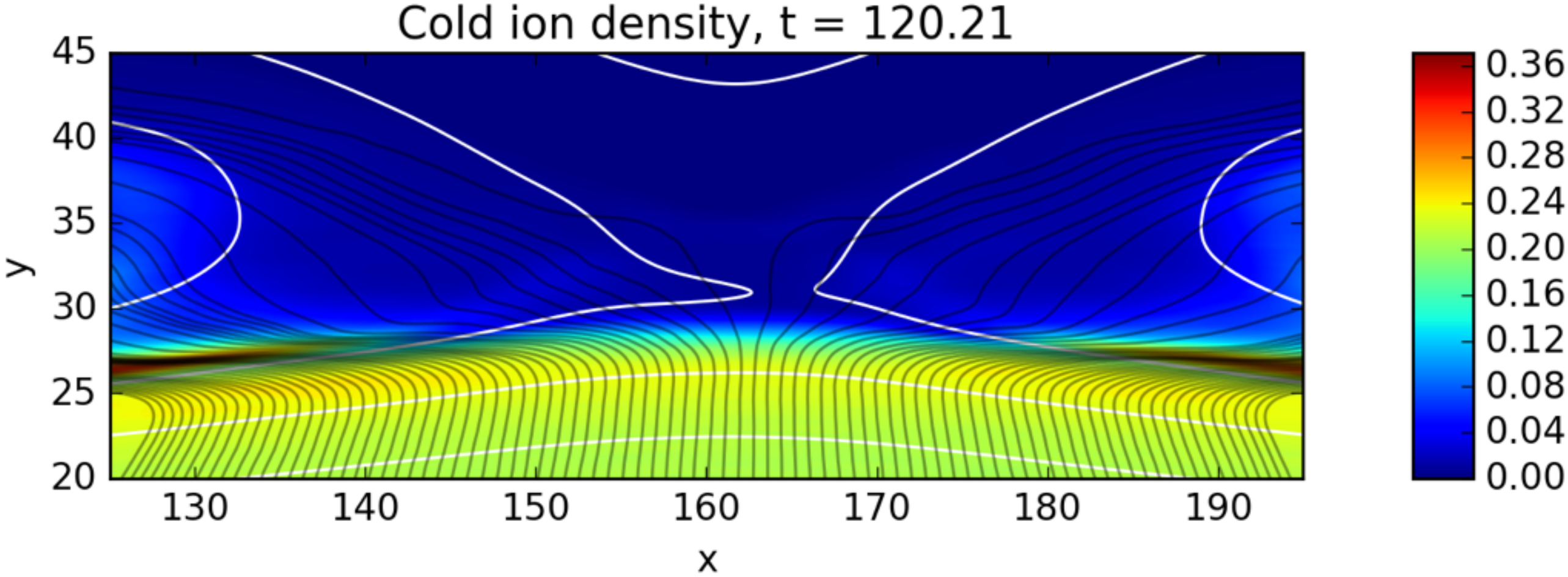


Larmor electric field comes from magnetosheath ion dynamics

Extended electric field comes from cold ion dynamics

Other cold ion signatures

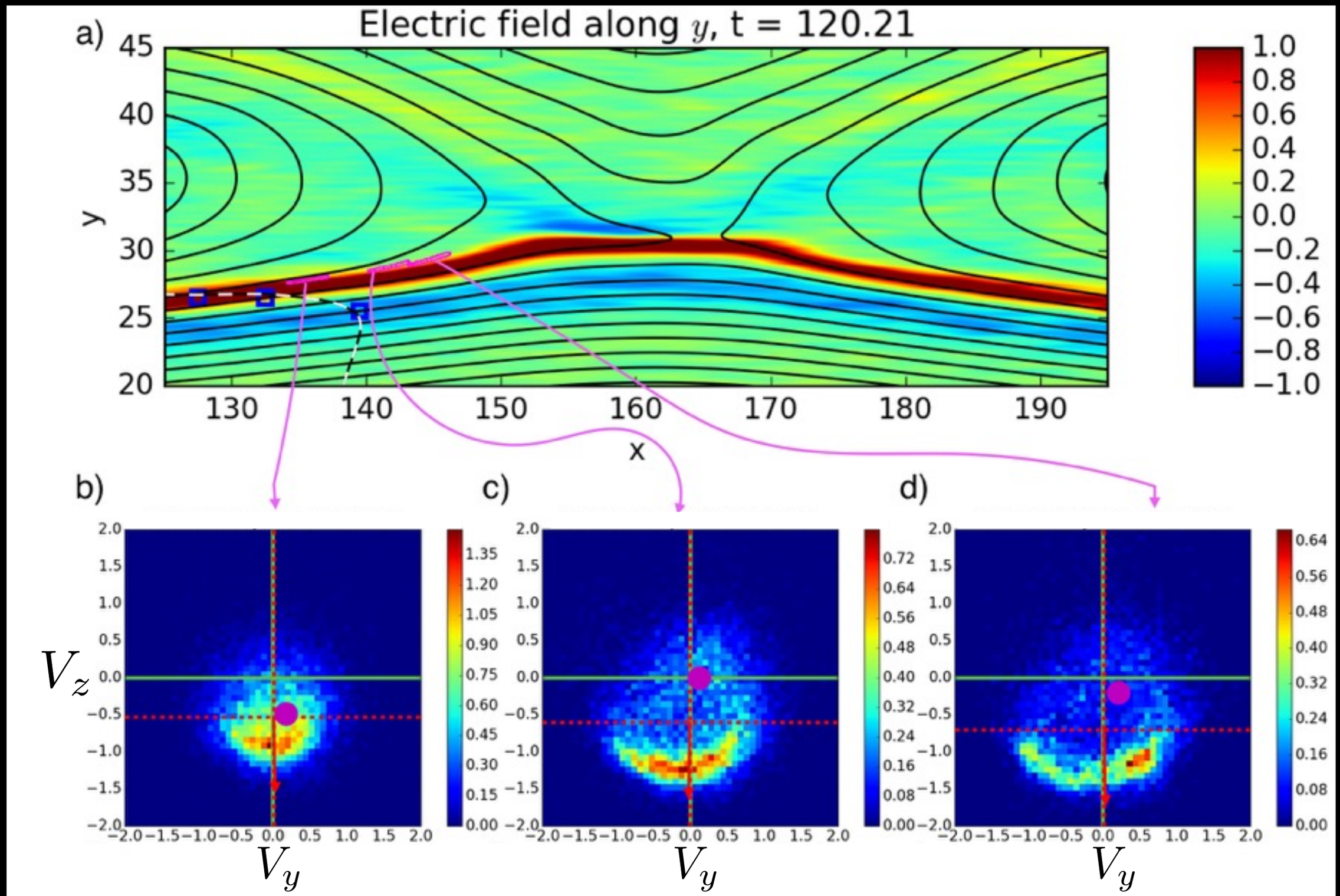
Rarefaction of cold ions in diffusion region and compression along separatrices



Dargent et al. (to be submitted at JGR)

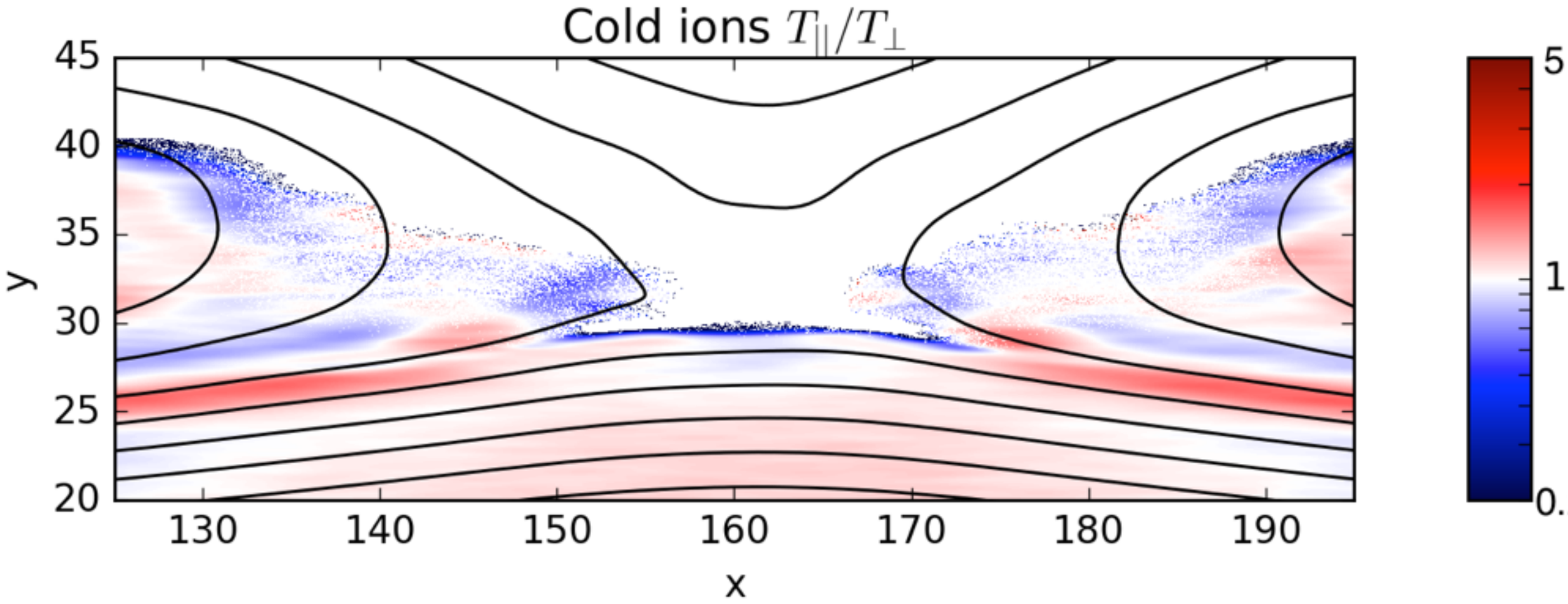
Other cold ion signatures

Crescent-shaped distribution function



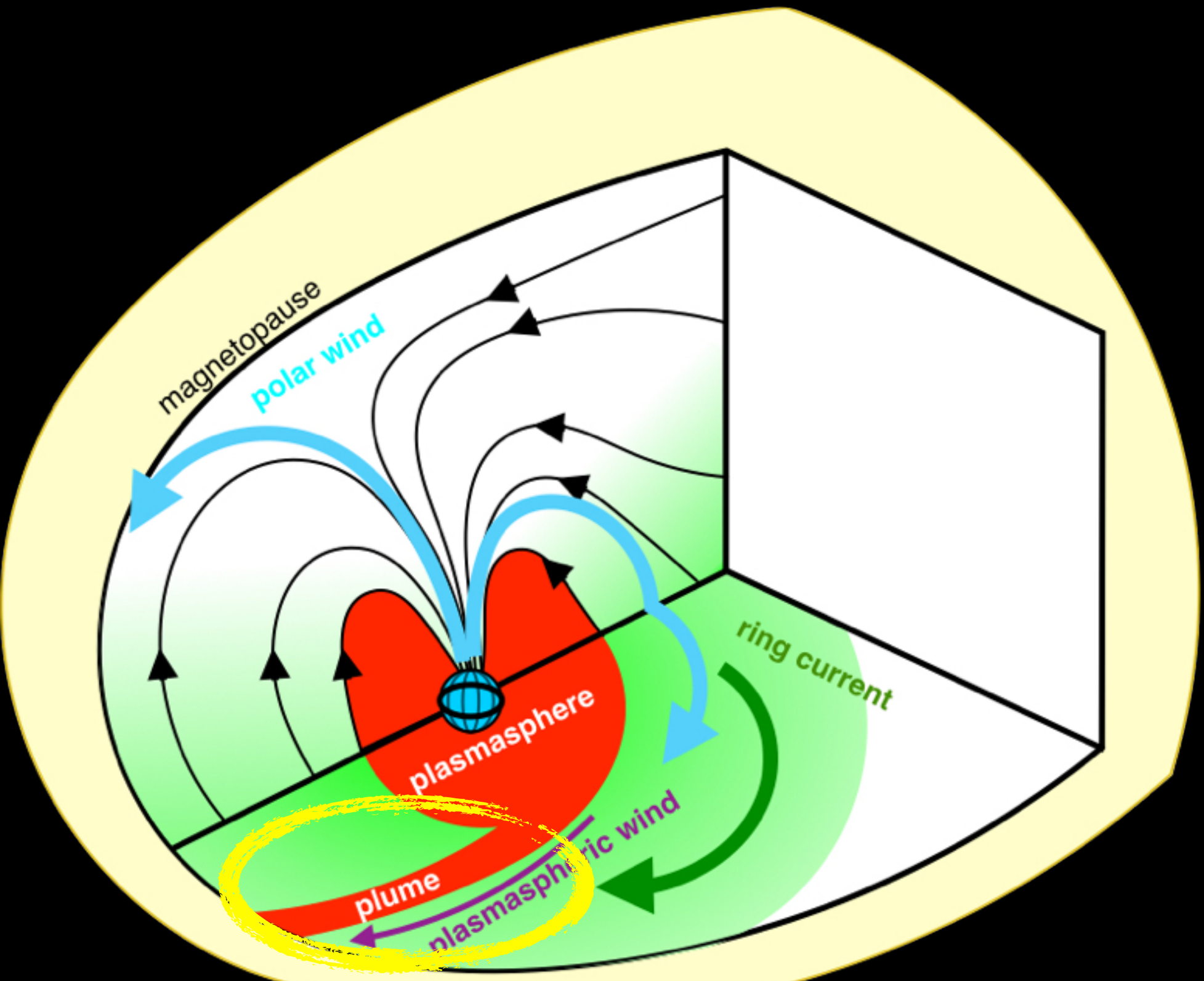
Other cold ion signatures

Parallel heating of cold ions along magnetospheric separatrices



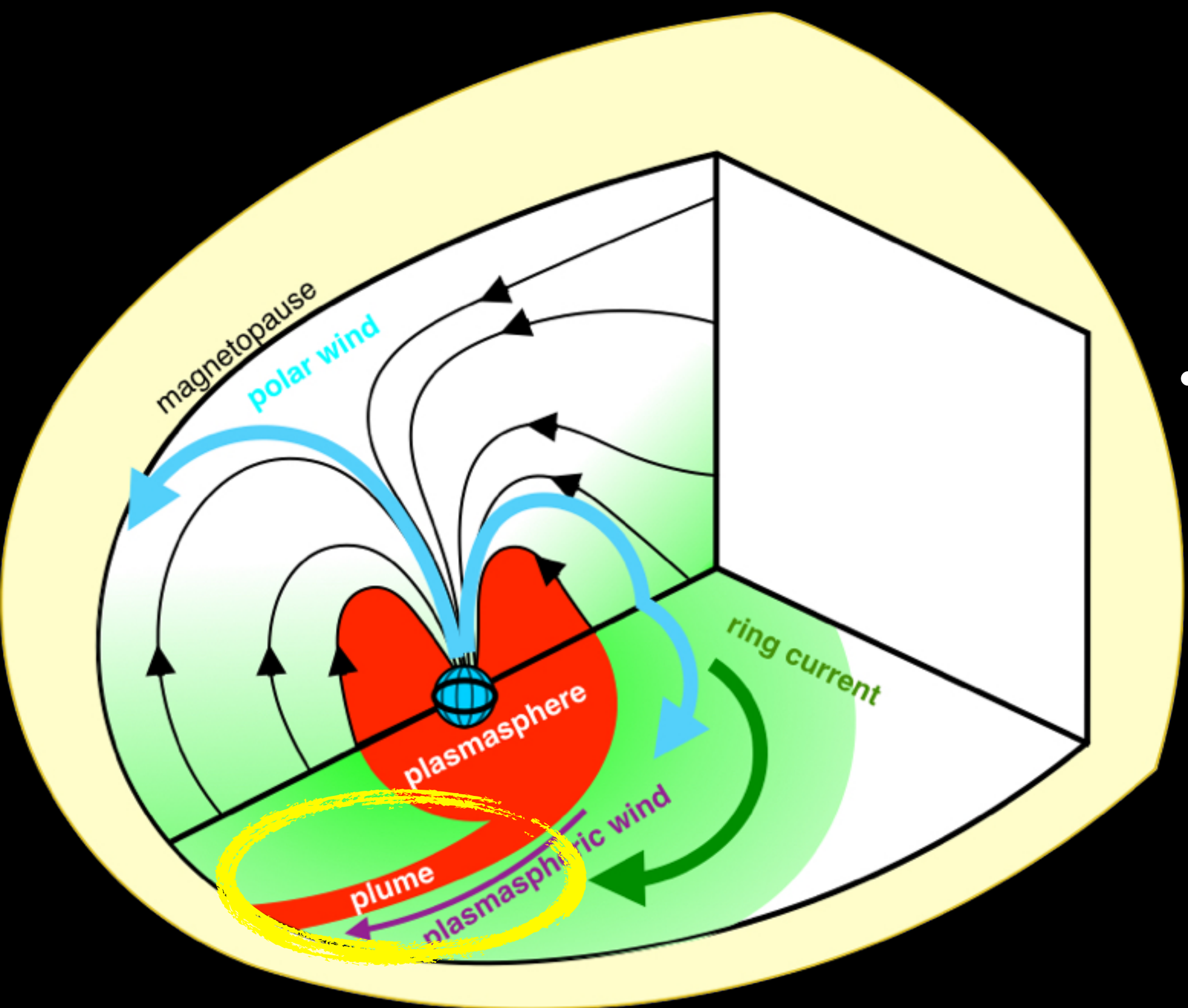
Dargent et al. (to be submitted at JGR)

Study of a plasmaspheric plume



- very dense
- very cold
- episodic

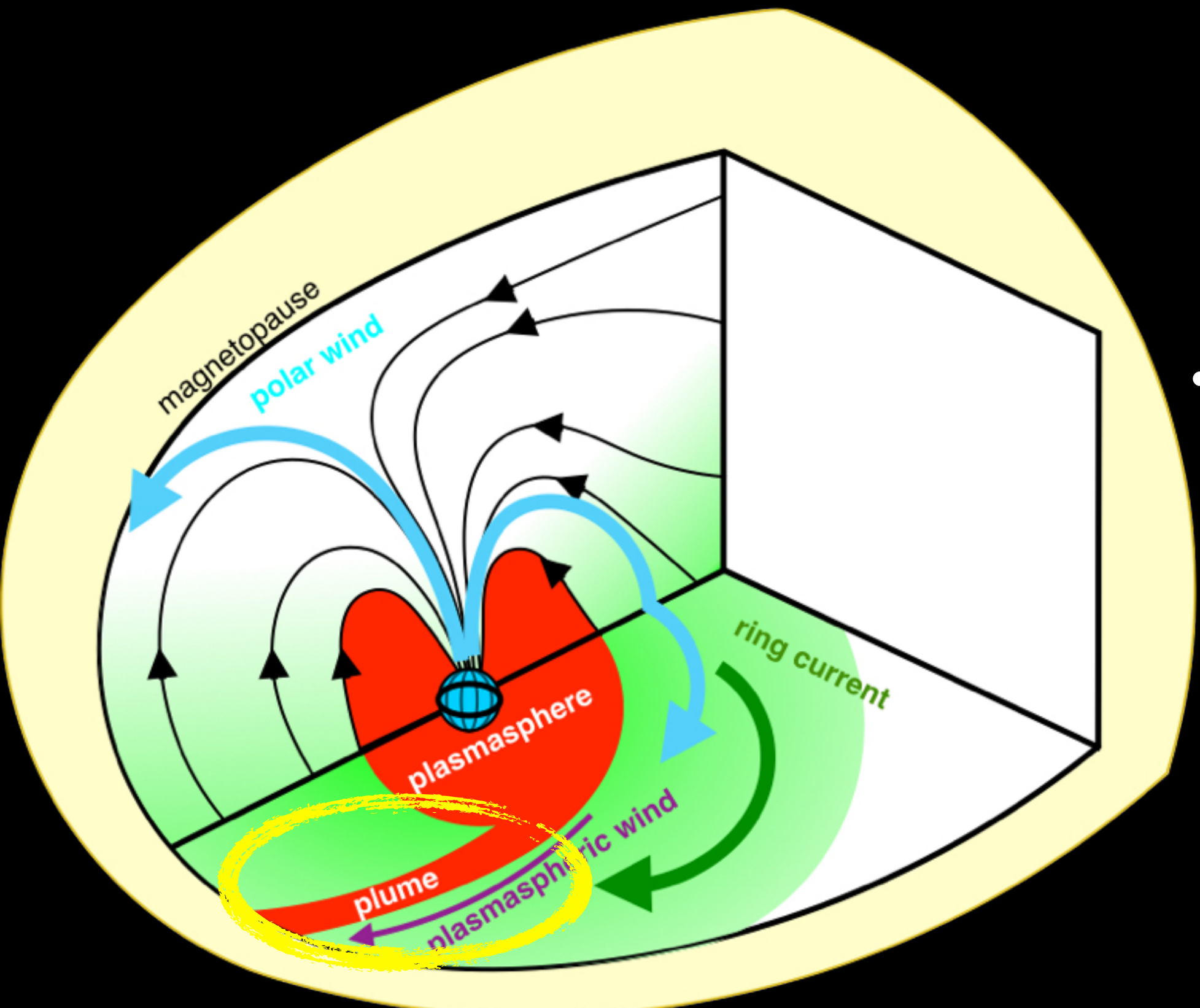
Study of a plasmaspheric plume



- First objective:

Study the impact of a plume

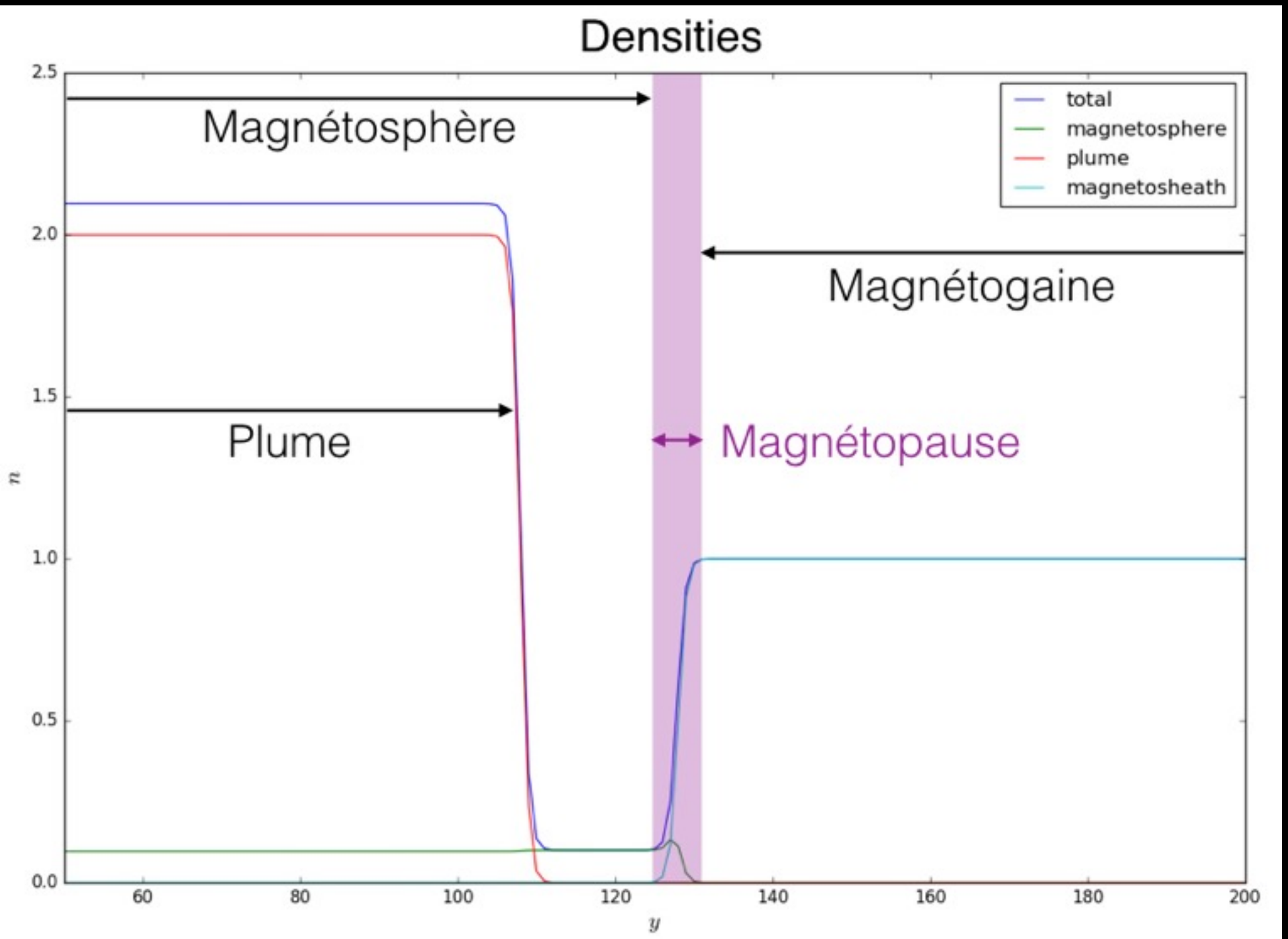
Study of a plasmaspheric plume



- Second objective:

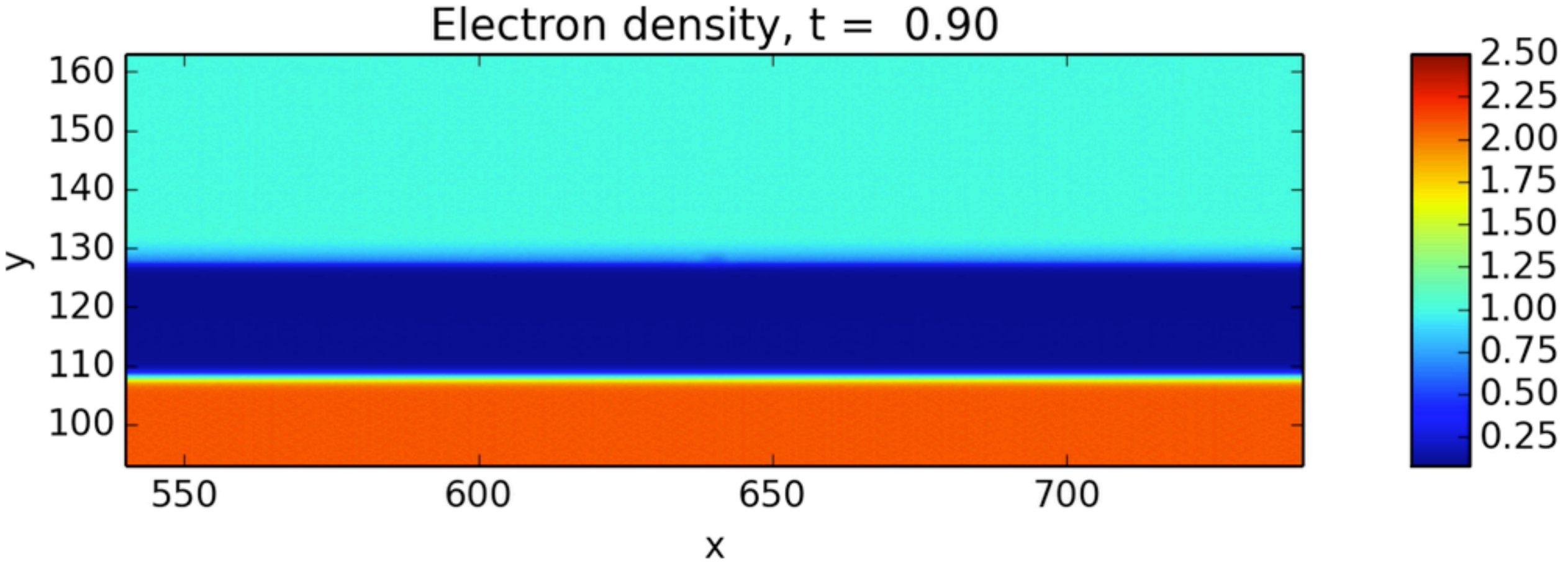
Study the far away exhaust

Study of a plasmaspheric plume



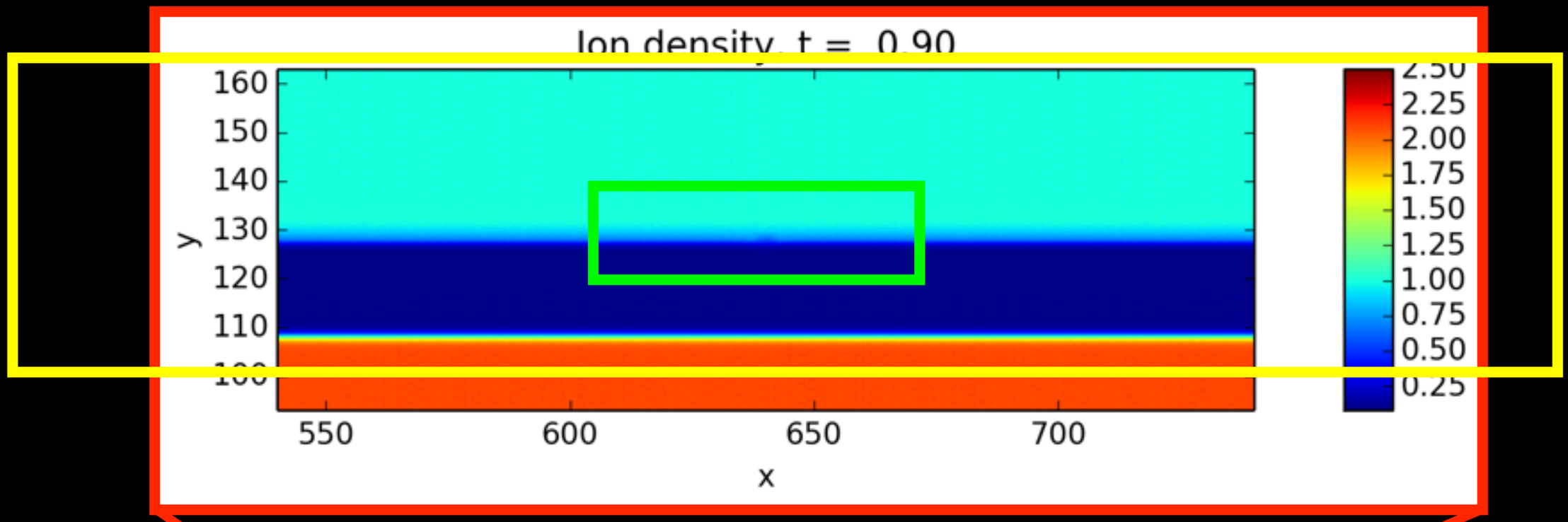
- 2D simulations
- Box size:
  25 600 * 10 240 cells
- Boundary condition:
  Periodic along x
  Reflective along y
- Computing center and machine:
  Curie at IDRIS

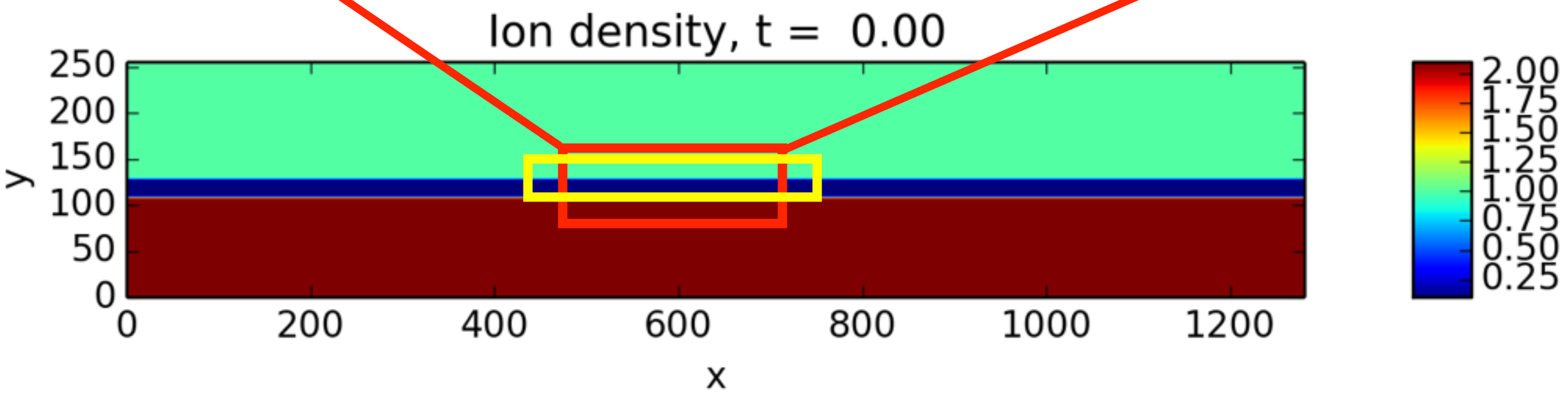
A large simulation in 3 steps



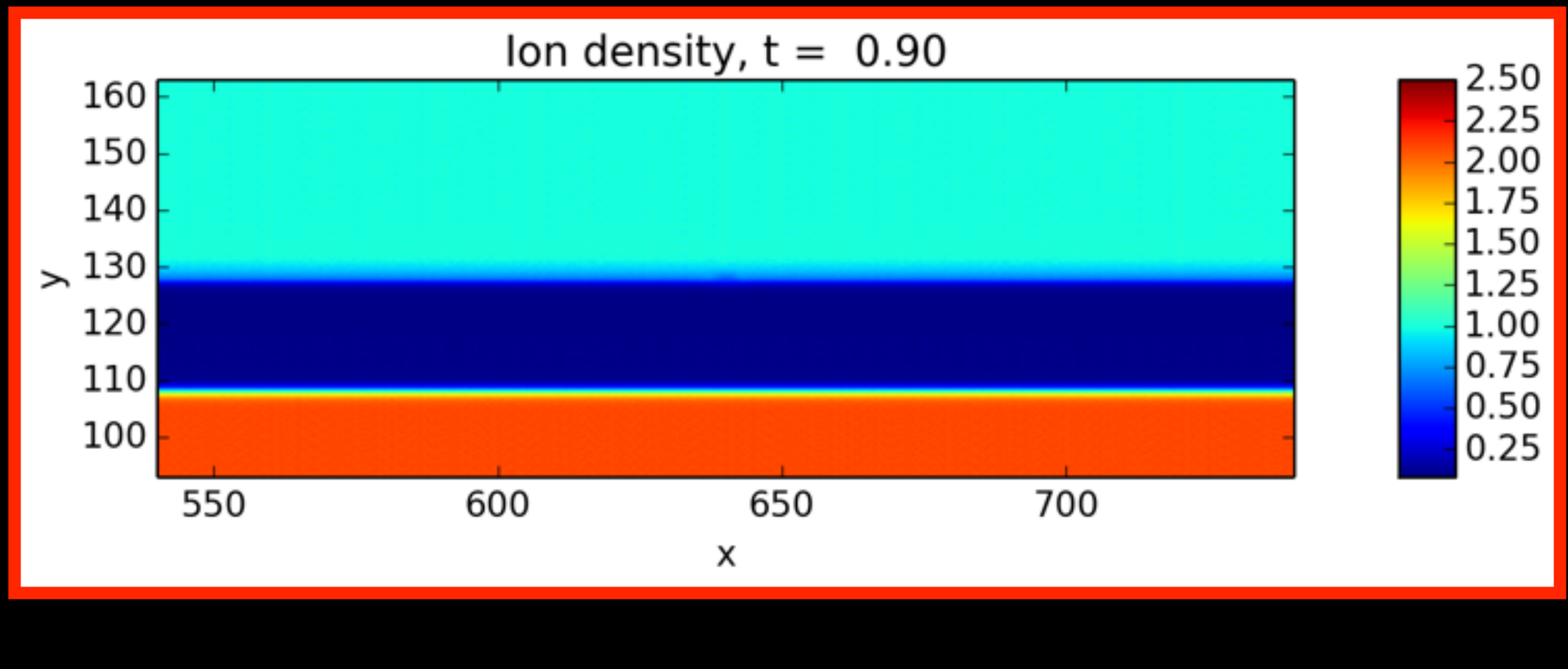
- Domain decomposition: 16384 cores (16*128 MPI process / 8 OpenMP threads)
- ~ 14 million CPU hours
- Data: ~ 350 To

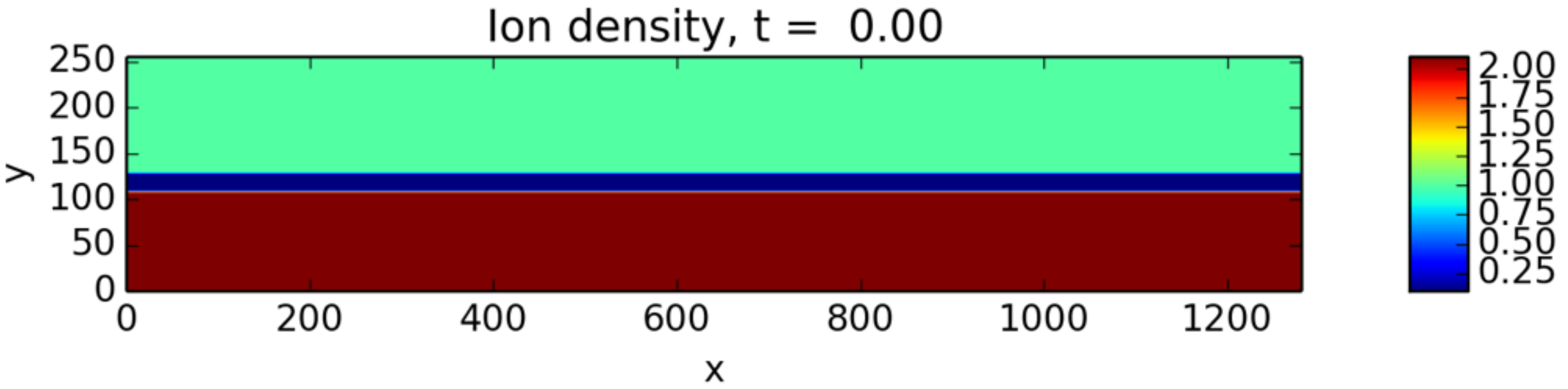
A large simulation in 3 steps





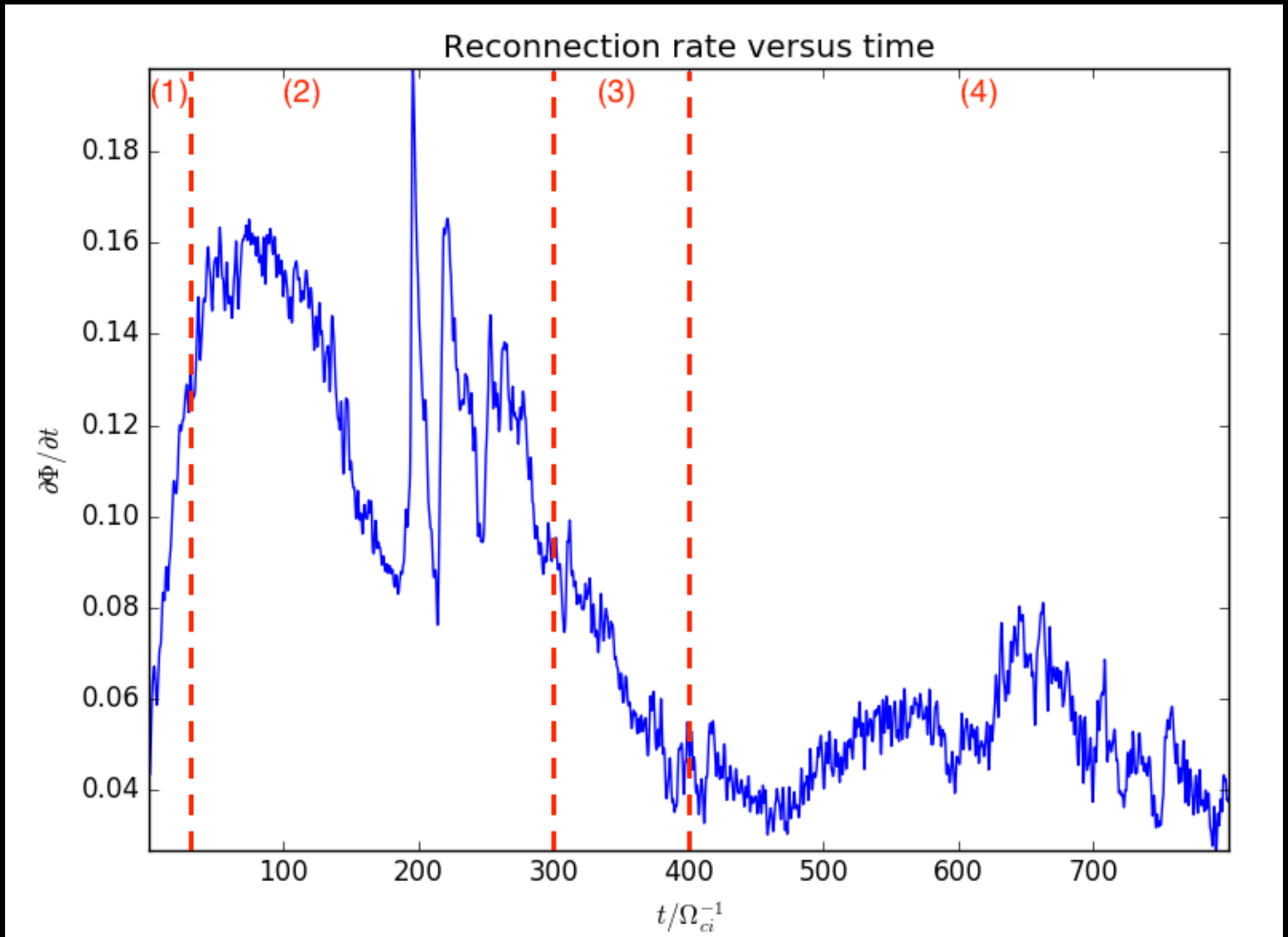
A large simulation in 3 steps





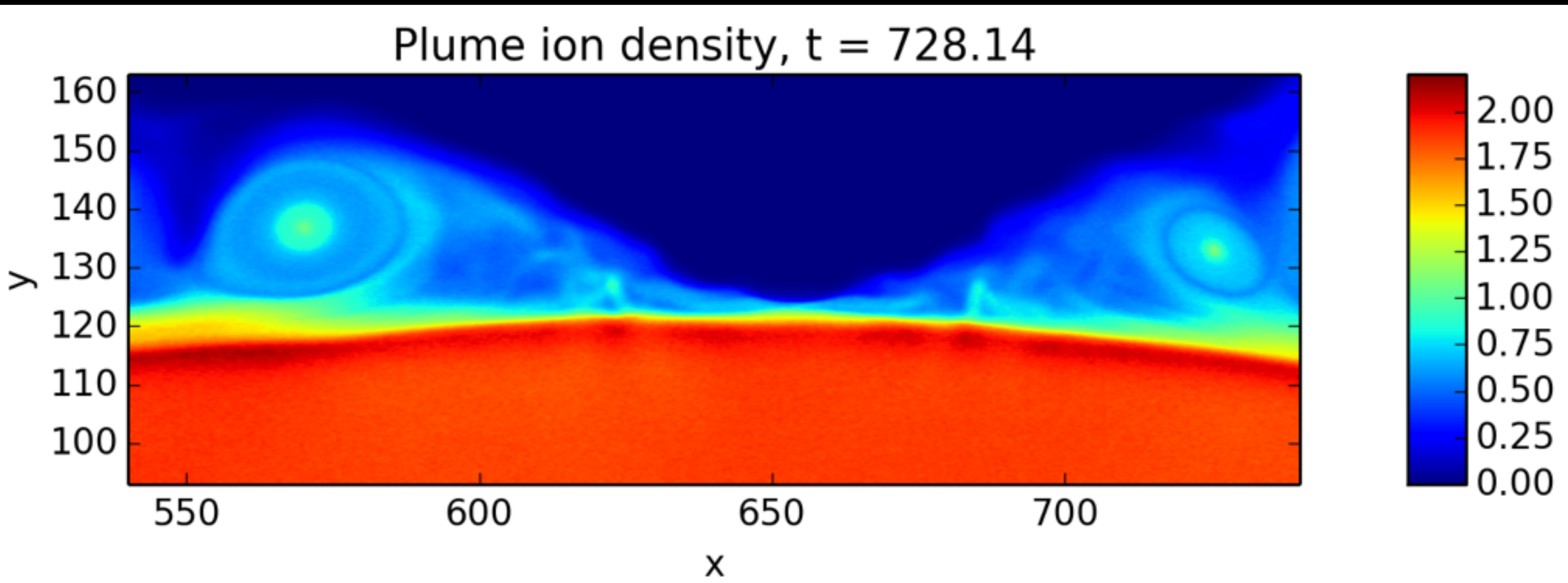
Ongoing work

The plume drop the reconnection rate



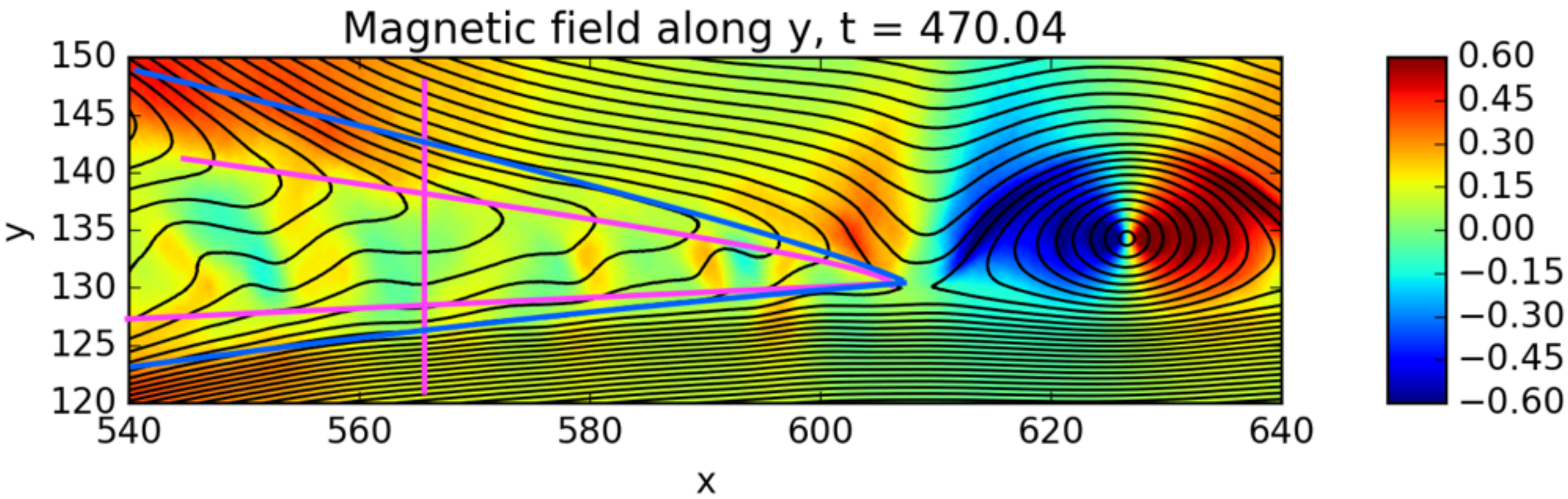
Ongoing work

Impact of the plume on plasmoids growth
&
Cold ion distribution in structures



Ongoing work

Observation of firehose instability
&
Impact of the plume on this unsteadiness



Conclusion

- SMILEI allowed unprecedented works in magnetic reconnection domain
- It can be used for light simulation as well as very heavy ones
- The possibility to easily define various populations was very useful for me