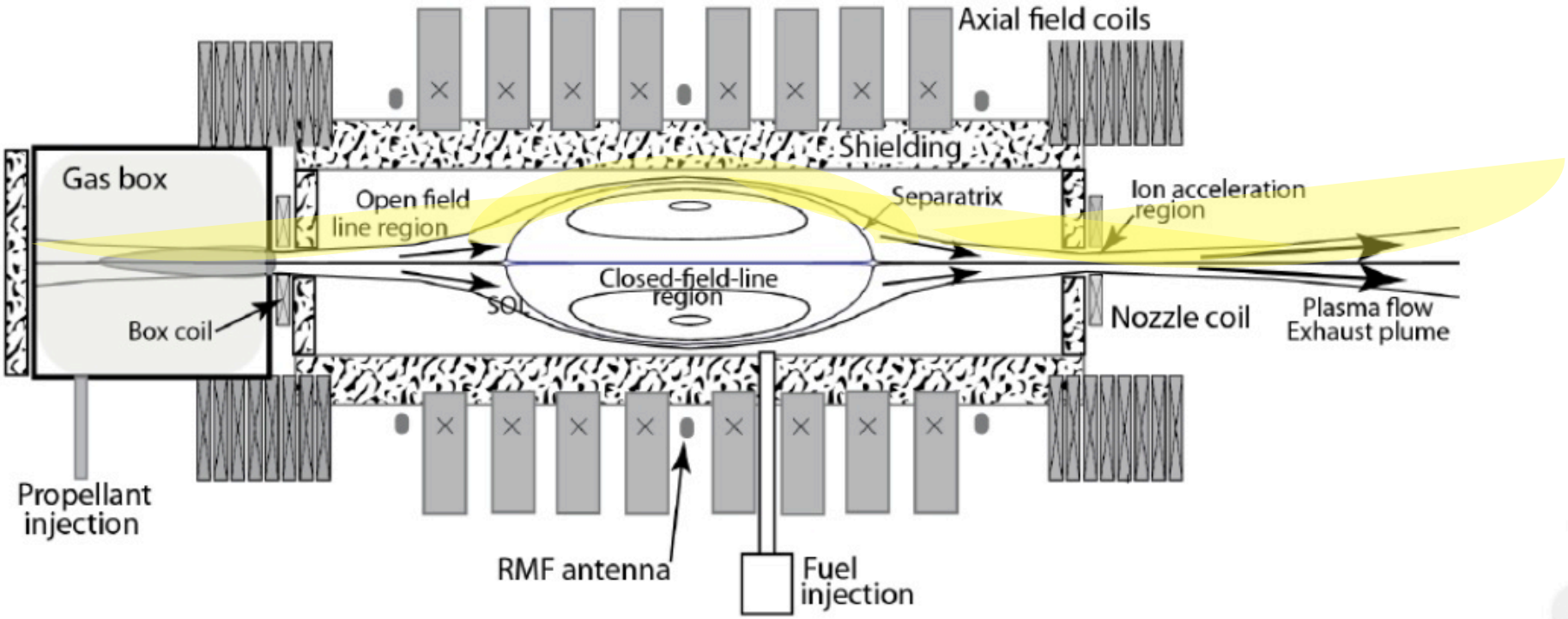
UEDGE Simulations for Power and Particle Flow Analysis of FRC

Fred Zheng

FRC ROCKET


Axial field coils
Shielding
Gas box
Open field
line region
Separatrix
Ion acceleration
region
Closed-field-line
region
SOL
Box coil
Nozzle coil
Plasma flow
Exhaust plume
Propellant
injection
RMF antenna
Fuel
injection

UEDGE

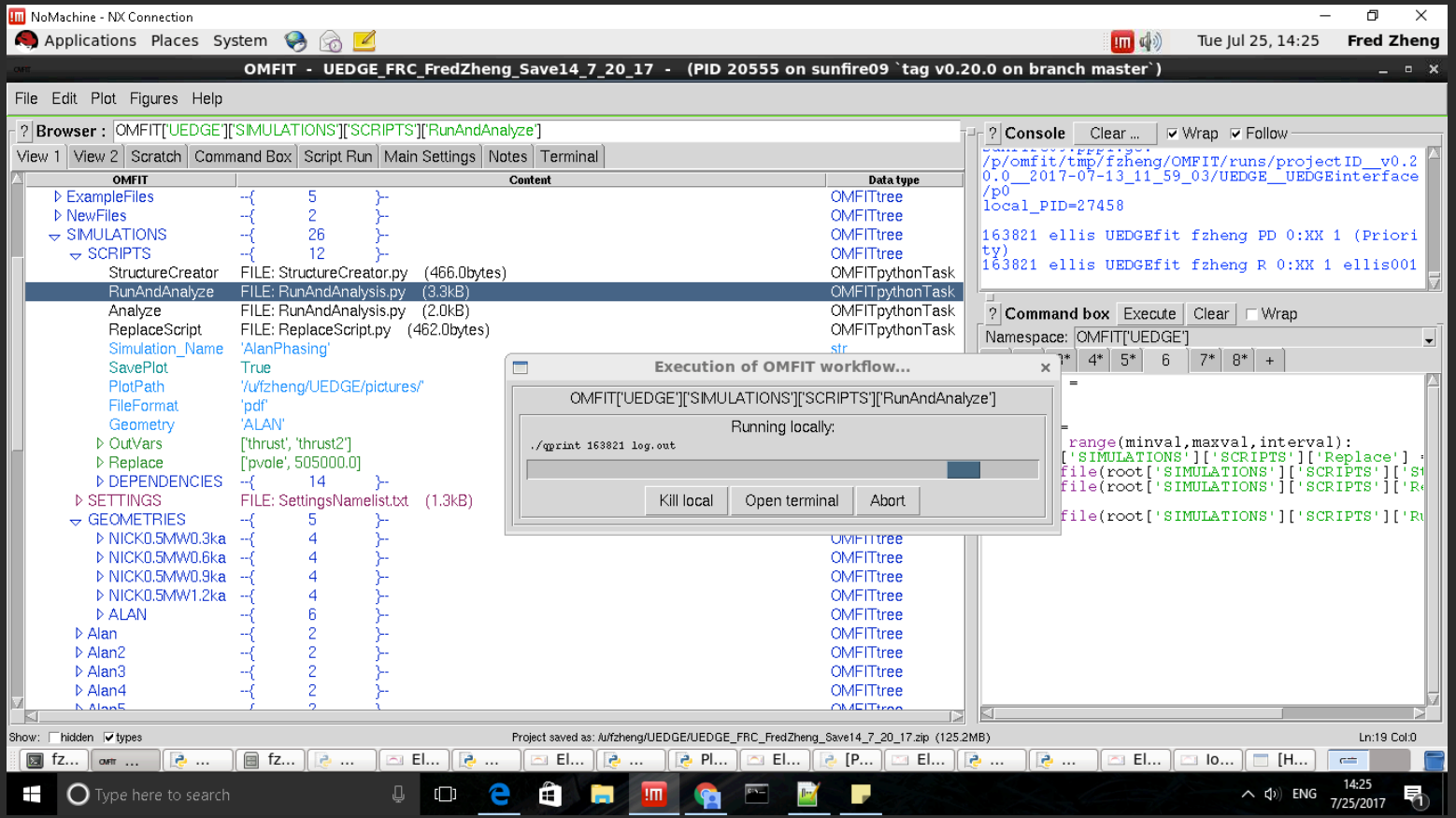
-2D multi-species fluid code used to model the SOL region of fusion reactors

-It does a modified Newton’s iteration to find a steady state self consistent solution to continuity equations, momentum equations, and energy equations

-The equations and transport coefficients are taken from Braginskii

-Takes a magnetic geometry file as well as a parameters input file

OMFIT


NoMachine - NX Connection
Applications Places System
Tue Jul 25, 14:25 Fred Zheng
OMFIT - UEDGE_FRC_FredZheng_Save14_7_20_17 - (PID 20555 on sunfire09 `tag v0.20.0 on branch master`)
File Edit Plot Figures Help
Browser : OMFIT['UEDGE']['SIMULATIONS']['SCRIPTS']['RunAndAnalyze']
View 1 View 2 Scratch Command Box Script Run Main Settings Notes Terminal
OMFIT Content Data type
ExampleFiles --{ 5 }-- OMFITtree
NewFiles --{ 2 }-- OMFITtree
SIMULATIONS --{ 26 }-- OMFITtree
SCRIPTS --{ 12 }-- OMFITtree
StructureCreator FILE: StructureCreator.py (466.0bytes) OMFITpythonTask
RunAndAnalyze FILE: RunAndAnalysis.py (3.3kB) OMFITpythonTask
Analyze FILE: RunAndAnalysis.py (2.0kB) OMFITpythonTask
ReplaceScript FILE: ReplaceScript.py (462.0bytes) OMFITpythonTask
Simulation_Name 'AlanPhasing' str
SavePlot True
PlotPath '/u/fzheng/UEDGE/pictures/'
FileFormat 'pdf'
Geometry 'ALAN'
OutVars ['thrust', 'thrust2']
Replace ['pvole', 505000.0]
DEPENDENCIES --{ 14 }--
SETTINGS FILE: SettingsNamelist.txt (1.3kB)
GEOMETRIES --{ 5 }--
NICK0.5MW0.3ka --{ 4 }--
NICK0.5MW0.6ka --{ 4 }--
NICK0.5MW0.9ka --{ 4 }--
NICK0.5MW1.2ka --{ 4 }--
ALAN --{ 6 }--
Alan --{ 2 }--
Alan2 --{ 2 }--
Alan3 --{ 2 }--
Alan4 --{ 2 }--
Console Clear ... Wrap Follow
/p/omfit/tmp/fzheng/OMFIT/runs/projectID__v0.20.0__2017-07-13_11_59_03/UEDGE__UEDGEinterface/p0
local_PID=27458
163821 ellis UEDGEfit fzheng PD 0:XX 1 (Priority)
163821 ellis UEDGEfit fzheng R 0:XX 1 ellis001
Command box Execute Clear Wrap
Namespace: OMFIT['UEDGE']
Execution of OMFIT workflow...
OMFIT['UEDGE']['SIMULATIONS']['SCRIPTS']['RunAndAnalyze']
Running locally:
./qprint 163821 log.out
Kill local Open terminal Abort
Show: hidden types
Project saved as: /u/fzheng/UEDGE/UEDGE_FRC_FredZheng_Save14_7_20_17.zip (125.2MB)
Ln:19 Col:0
Type here to search
ENG
14:25
7/25/2017

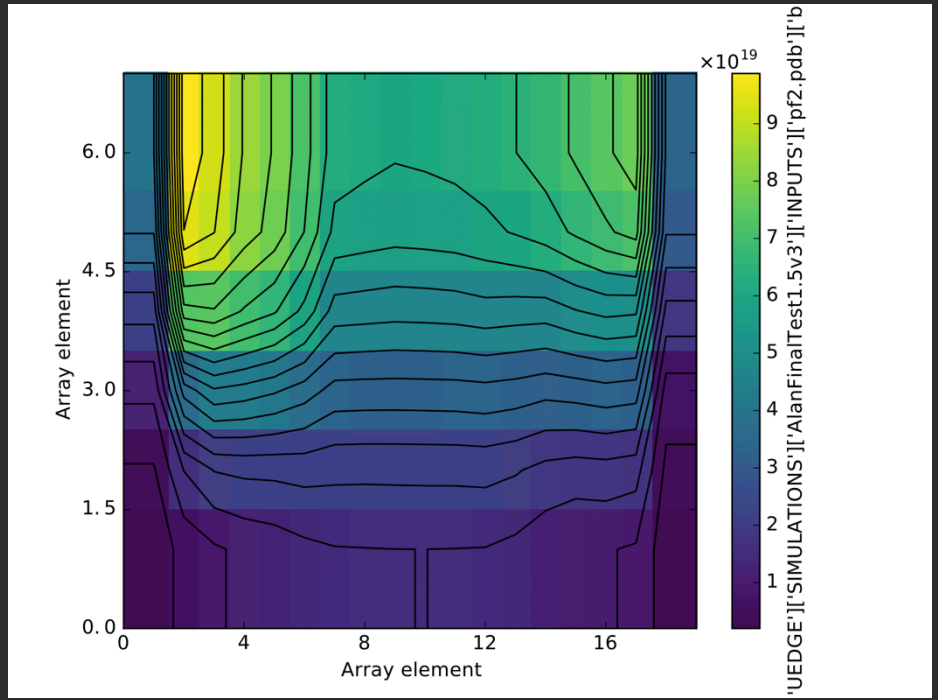
UEDGE Parameters

Grid Resolution

Power Source

Gas Source

Boundary Conditions



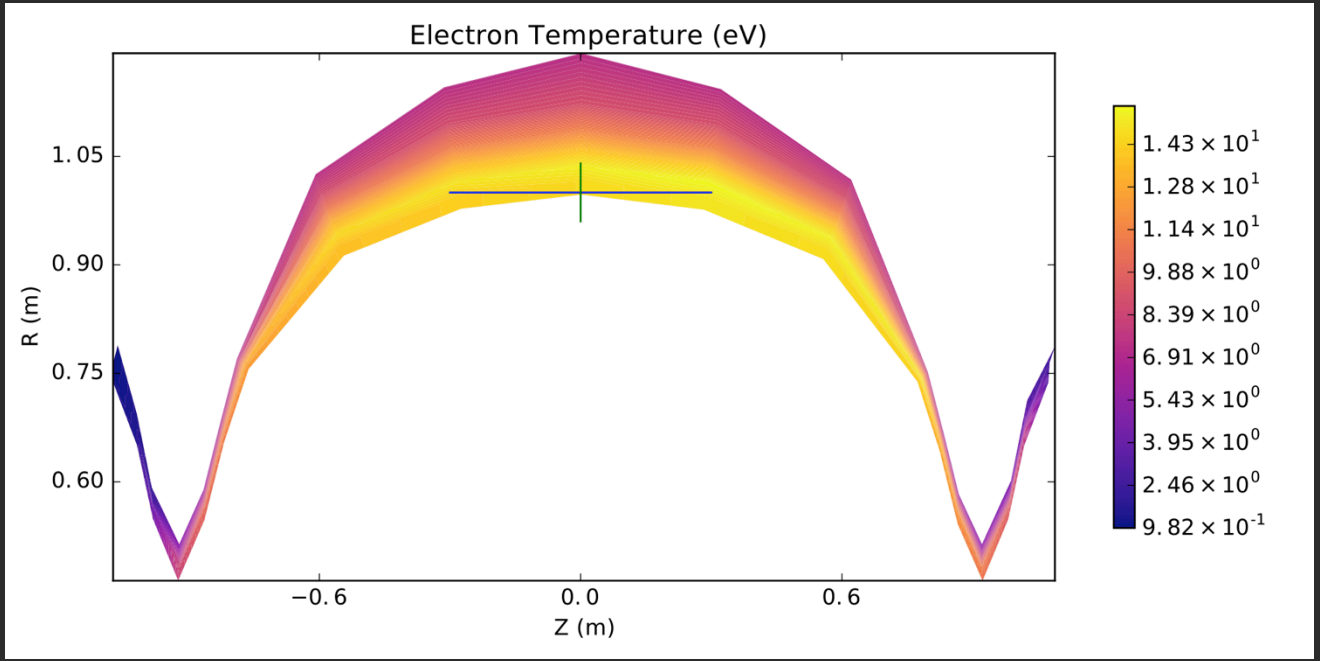
UEDGE Parameters

Grid Resolution

Power Source

Gas Source

Boundary Conditions



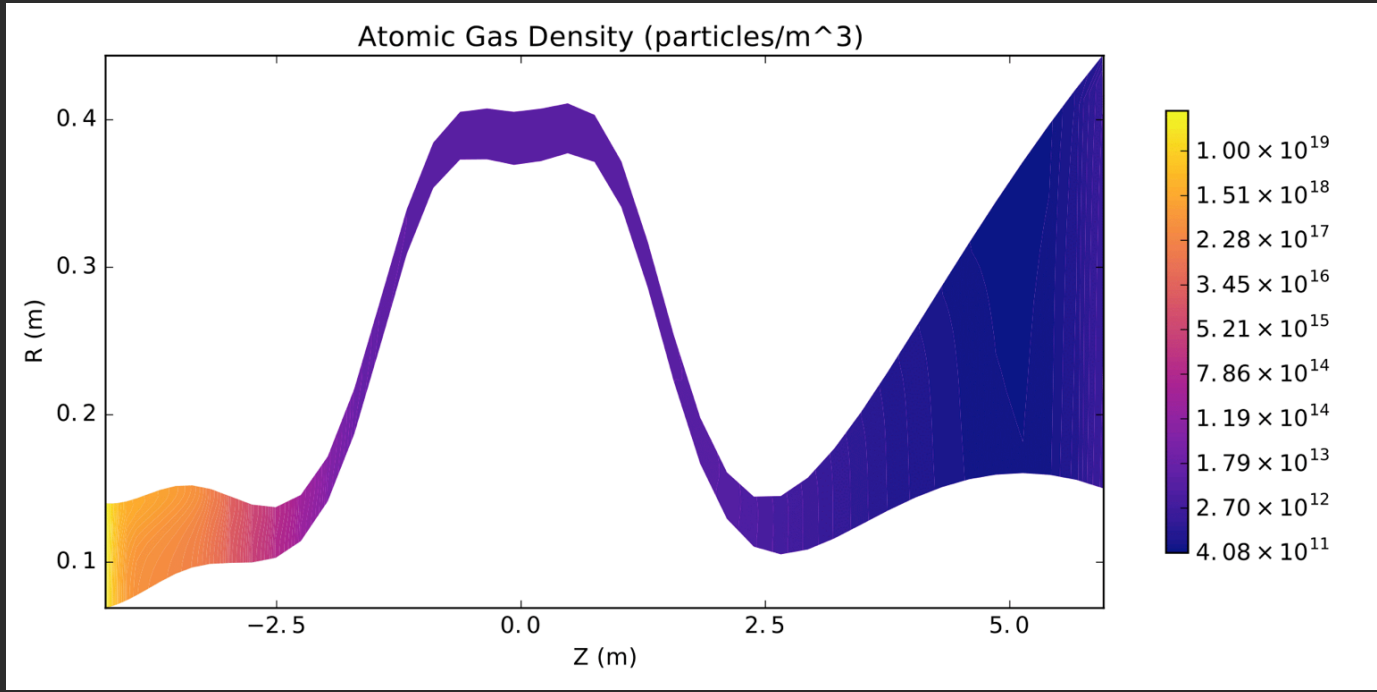
UEDGE Parameters

Grid Resolution

Power Source

Gas Source

Boundary Conditions



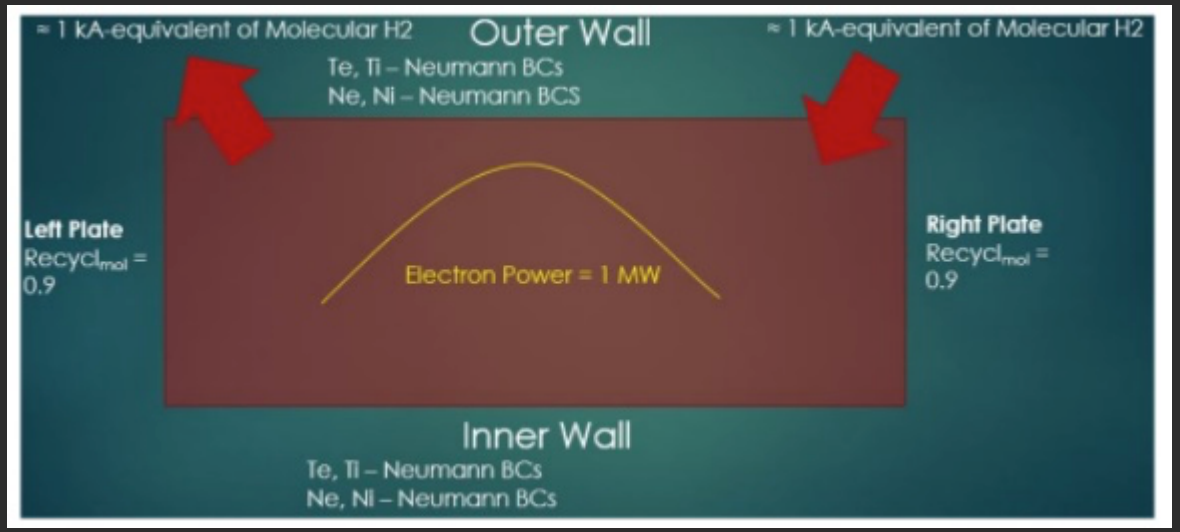
UEDGE Parameters

Grid Resolution

Power Source

Gas Source

Boundary Conditions



Power balance

Power into diverter plate

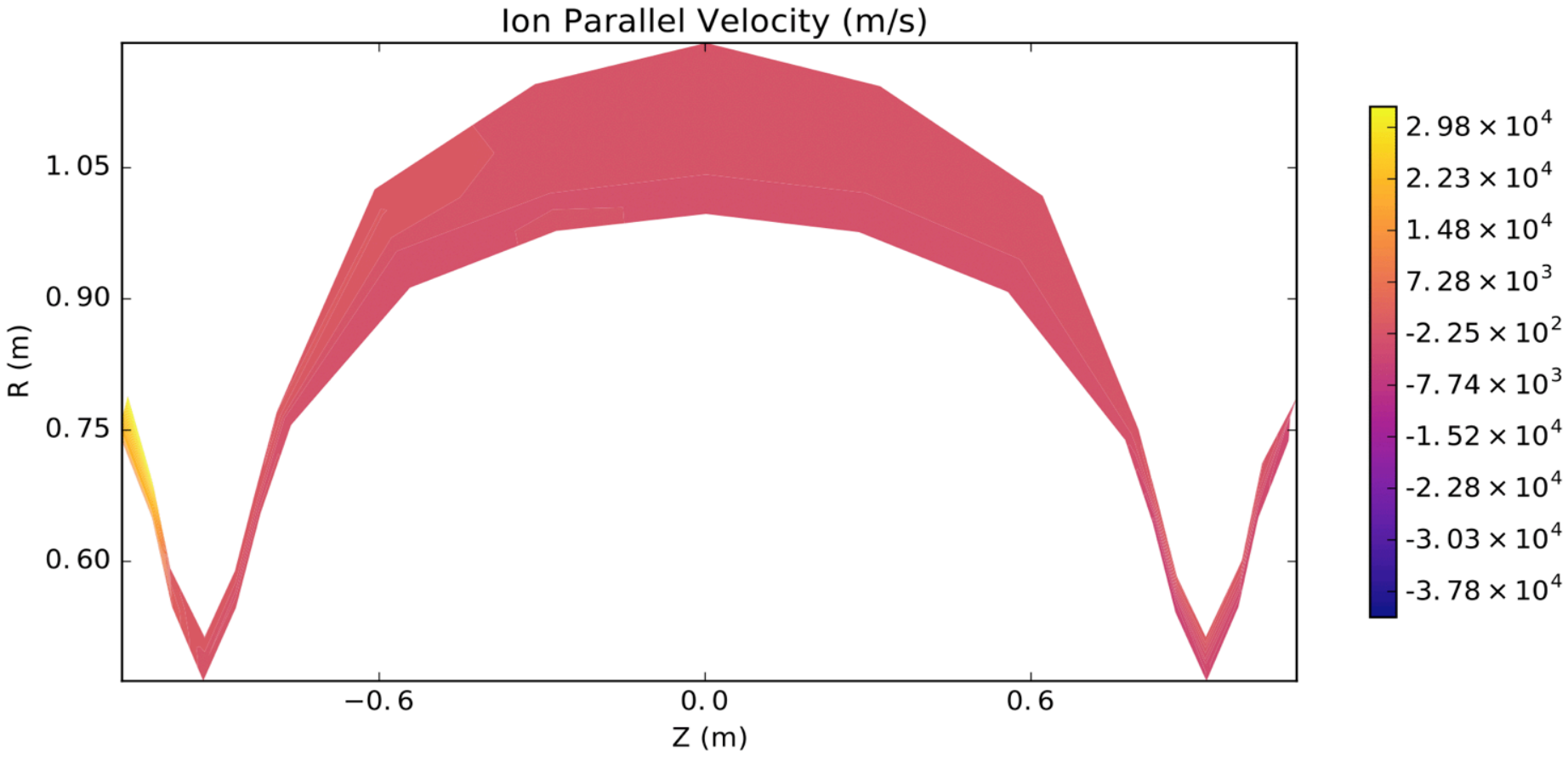
$$\tfrac{1}{2}\, m_{ion} * U_{||}^{2} * fnix$$

Power from binding energy during recycling

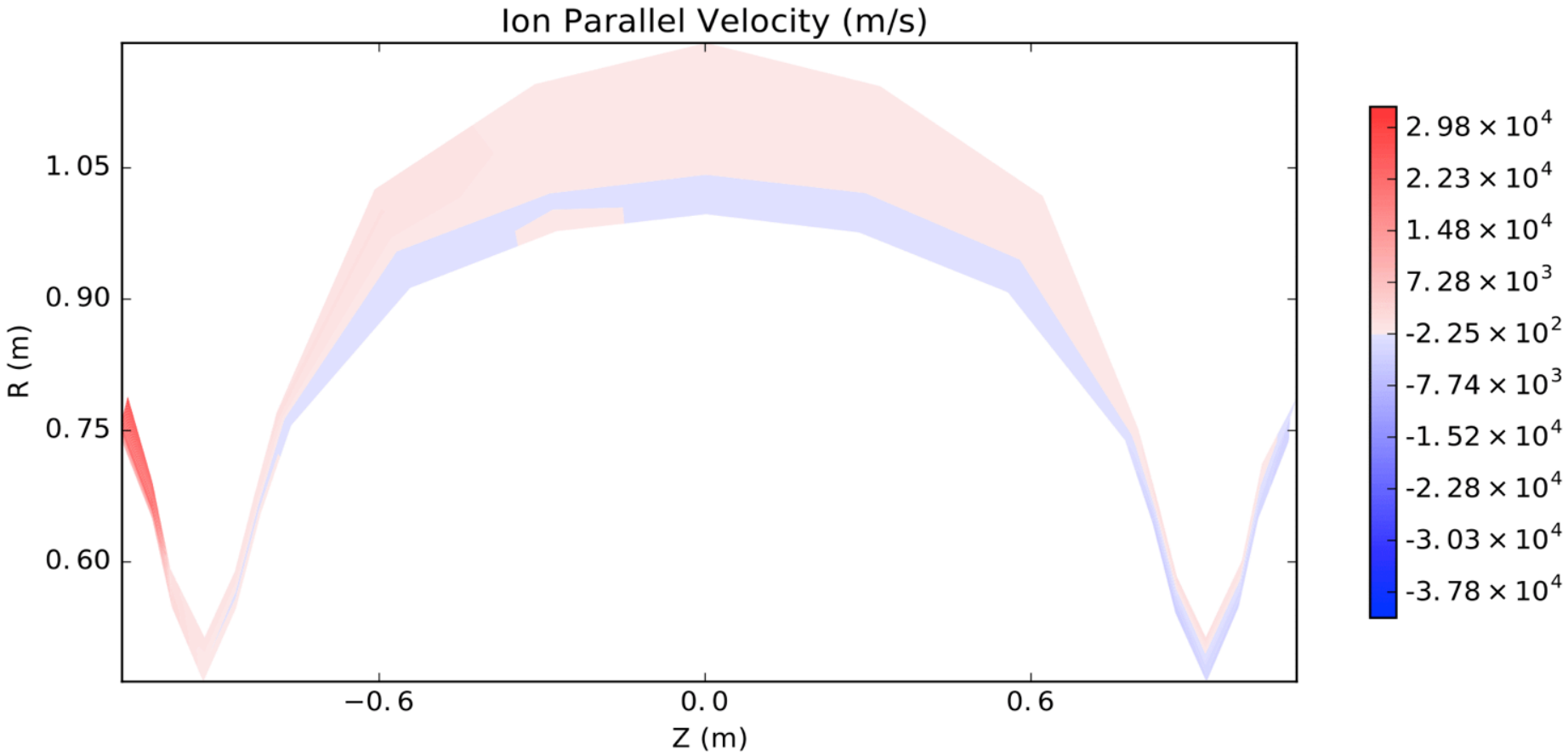
$$fnix * ebind*ev$$

Power from radiation

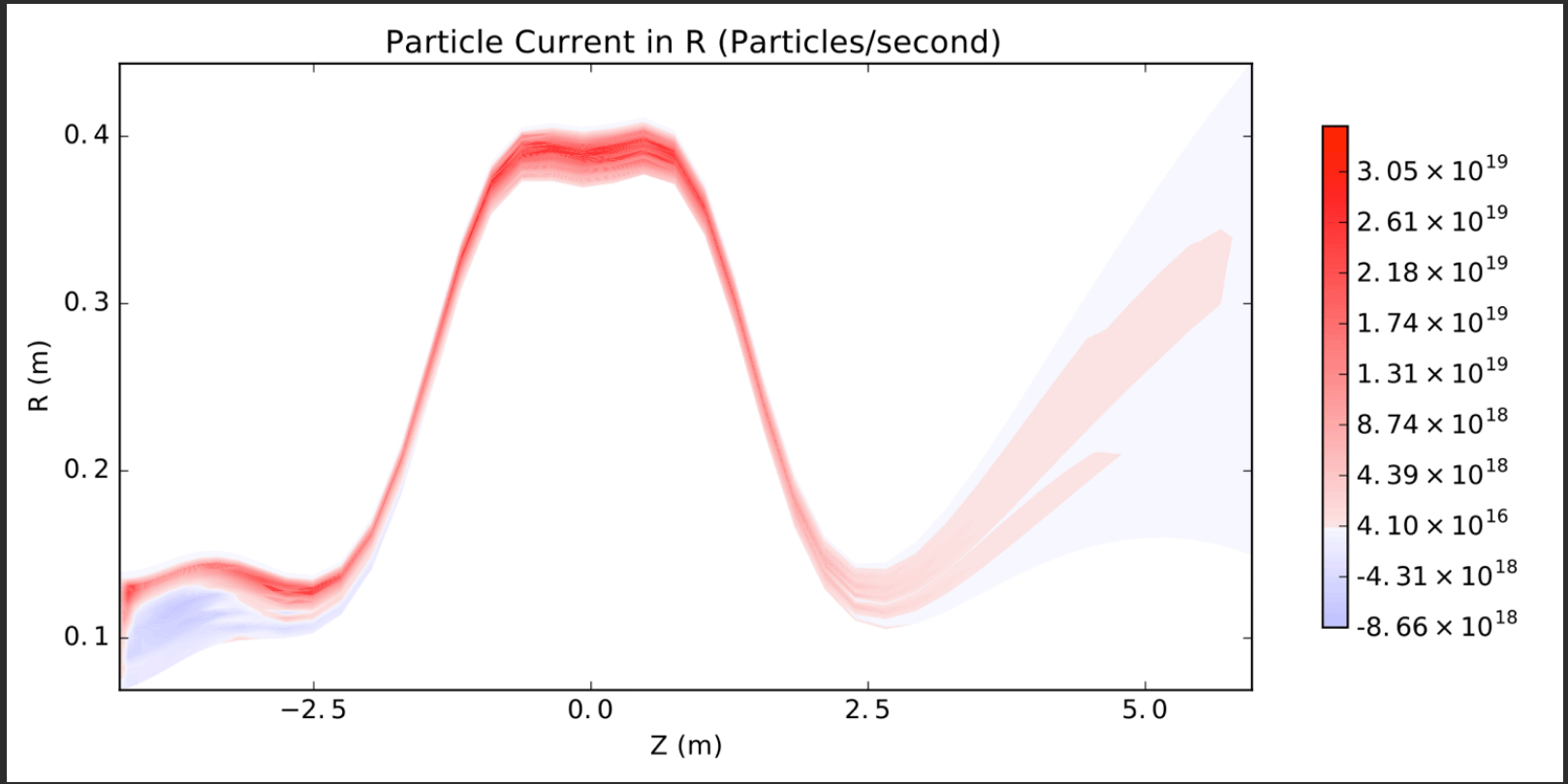
Colormap


Ion Parallel Velocity (m/s)
1.05
0.90
0.75
0.60
R (m)
−0.6
0.0
0.6
Z (m)
2.98 × 10^4
2.23 × 10^4
1.48 × 10^4
7.28 × 10^3
-2.25 × 10^2
-7.74 × 10^3
-1.52 × 10^4
-2.28 × 10^4
-3.03 × 10^4
-3.78 × 10^4

Colormap

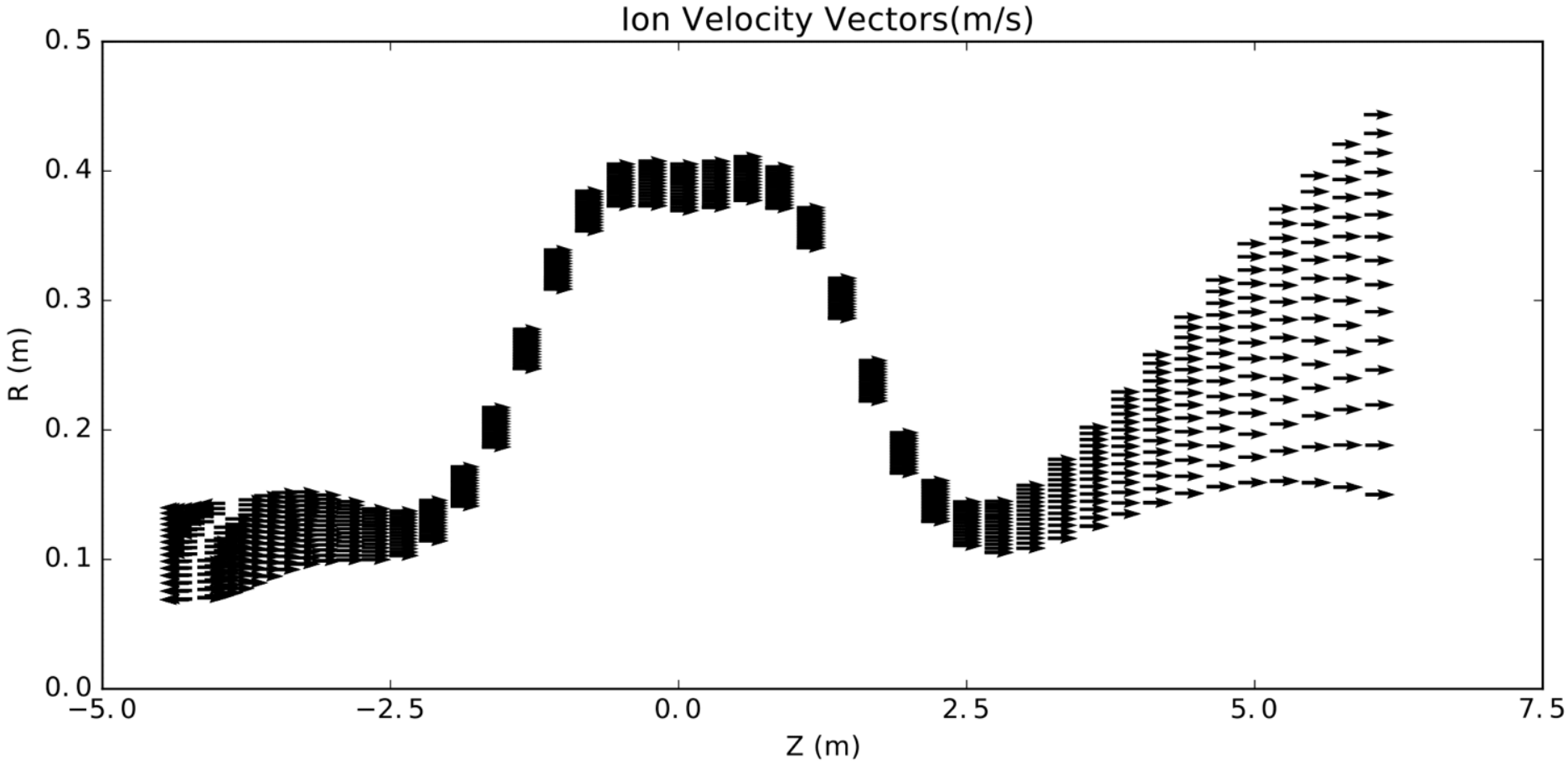

Ion Parallel Velocity (m/s)
1.05
0.90
0.75
0.60
R (m)
−0.6
0.0
0.6
Z (m)
2.98 × 10^4
2.23 × 10^4
1.48 × 10^4
7.28 × 10^3
-2.25 × 10^2
-7.74 × 10^3
-1.52 × 10^4
-2.28 × 10^4
-3.03 × 10^4
-3.78 × 10^4

New Plots

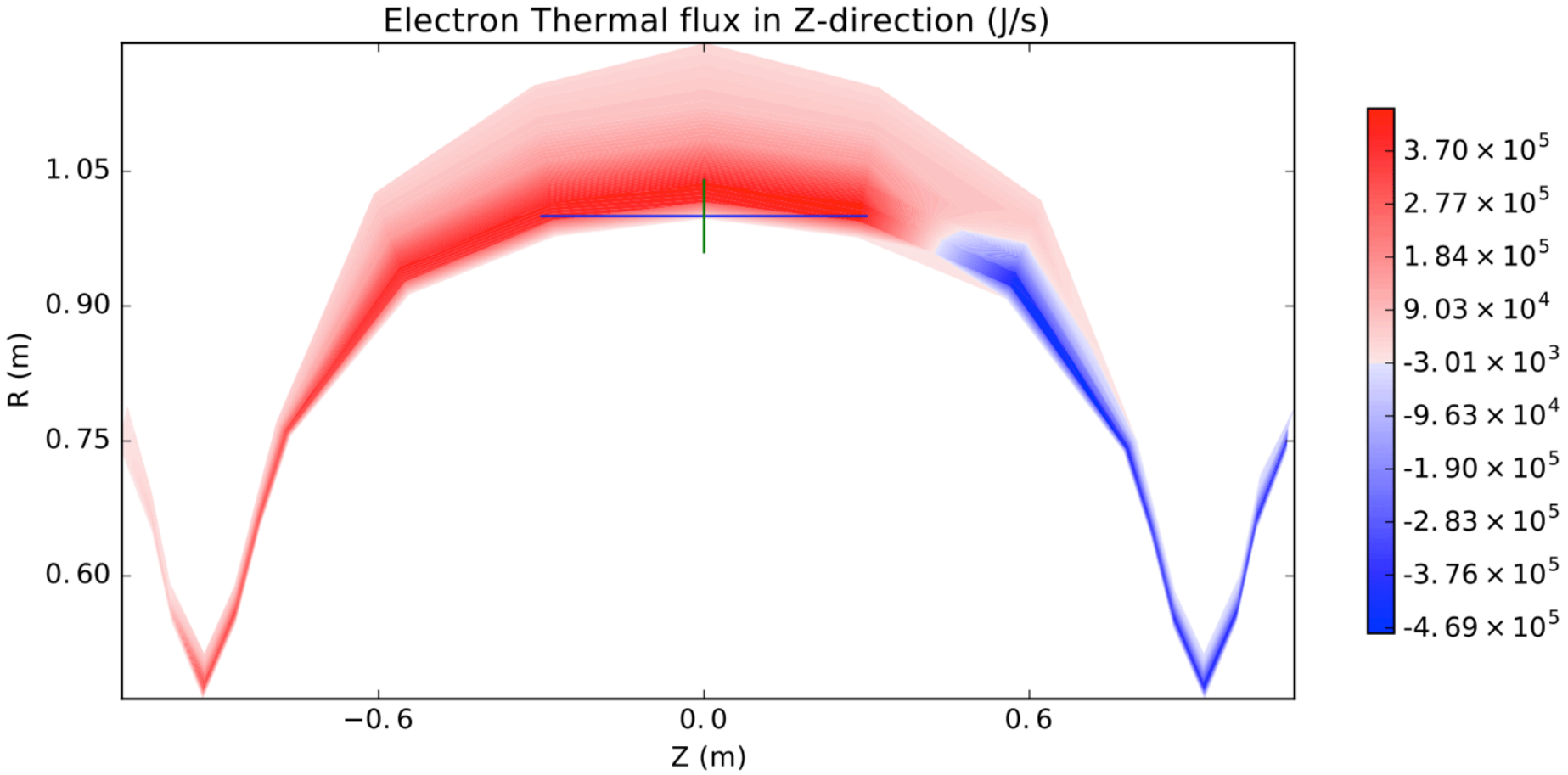


Nick0.50MW0.6kA

New Plots



New Plots

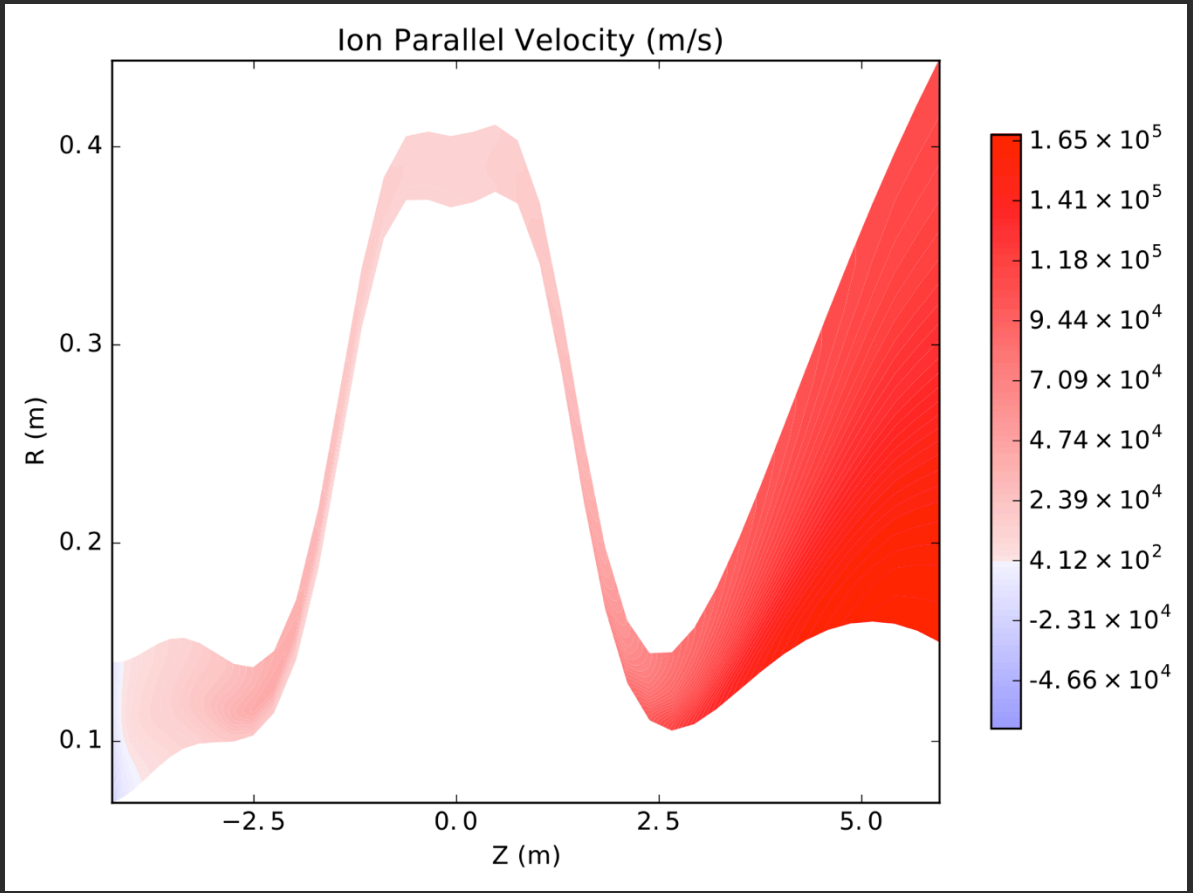

Electron Thermal flux in Z-direction (J/s)
1.05
0.90
0.75
0.60
R (m)
−0.6
0.0
0.6
Z (m)
3.70 × 10^5
2.77 × 10^5
1.84 × 10^5
9.03 × 10^4
-3.01 × 10^3
-9.63 × 10^4
-1.90 × 10^5
-2.83 × 10^5
-3.76 × 10^5
-4.69 × 10^5

Nick

-Rocket configuration

-One gas source

-Flux boundary condition

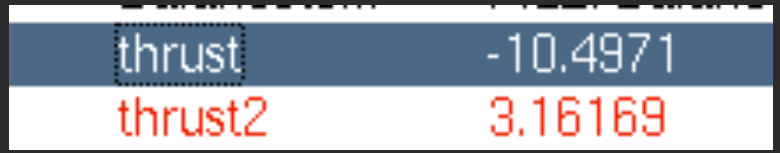


Updated Thrust Calculation

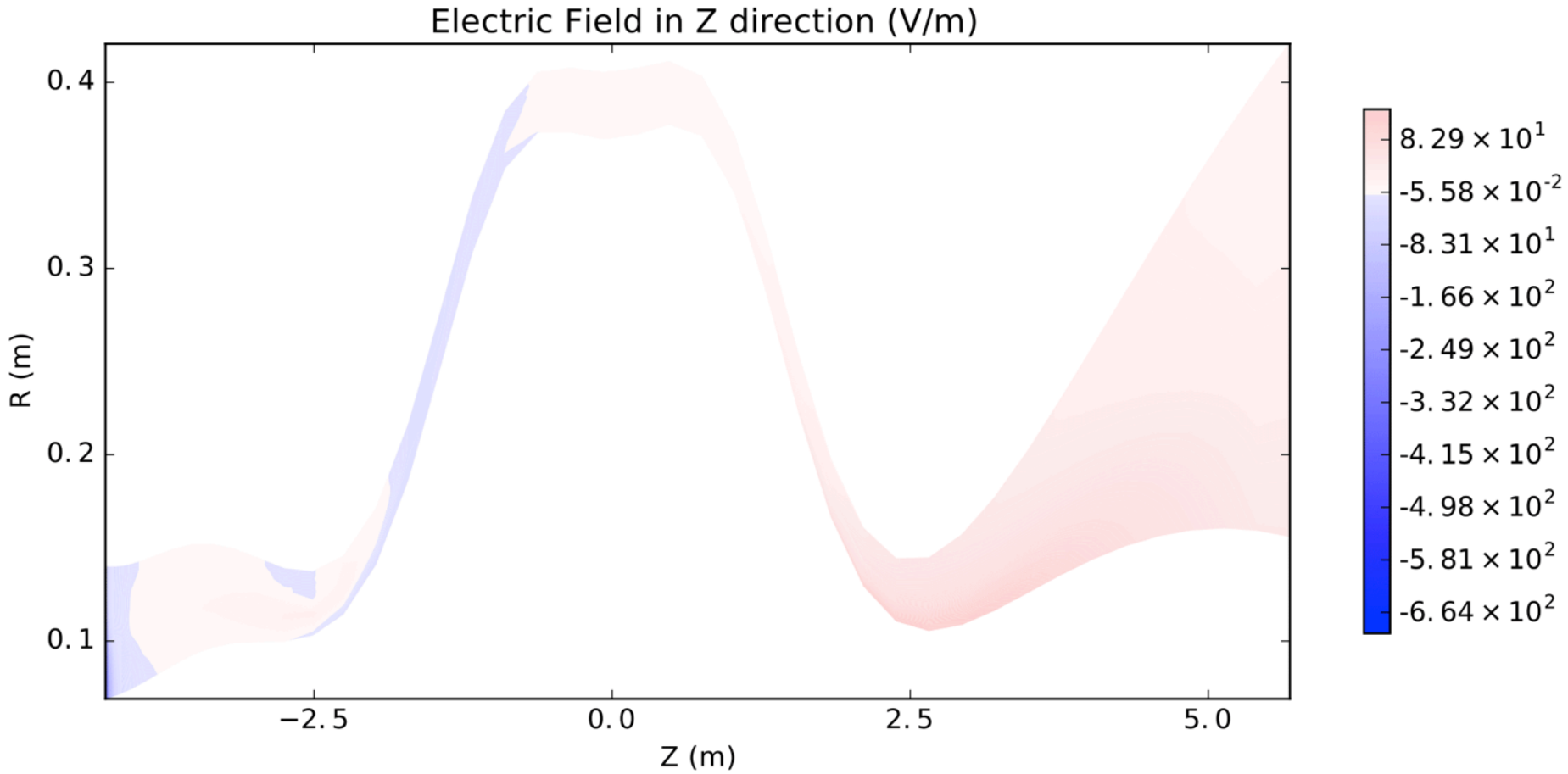
Old thrust = m_{ion} * fnix* $U_{||}$ ***bz/btot**

New thrust= **fmix* bz/btot**

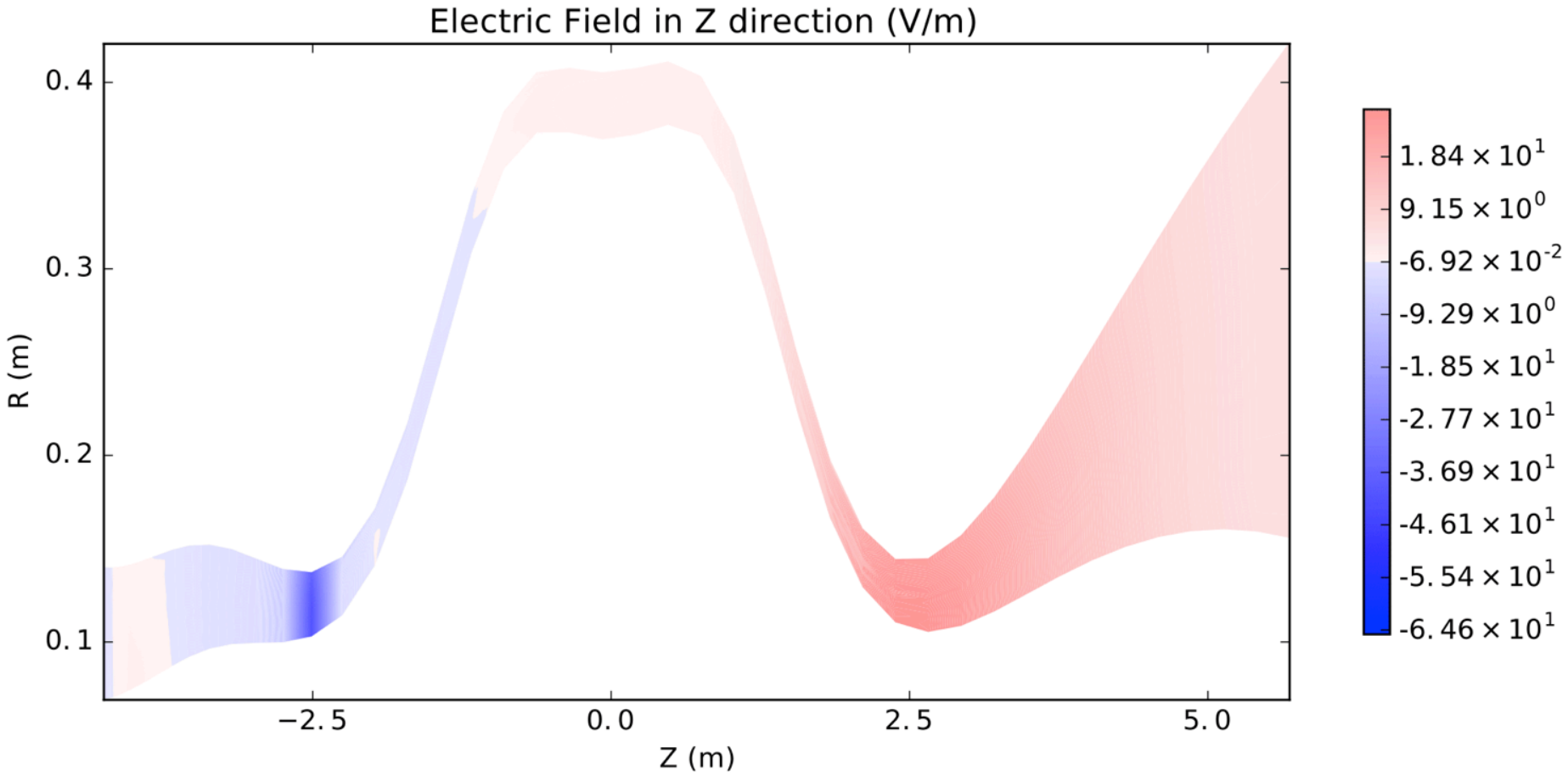
fmix = (mi*ni*up*rrv*up – visx*dup/dx)*sx



Nick0.50MW0.3kA



Nick0.50MW1.2kA



Alan

Weird power balance

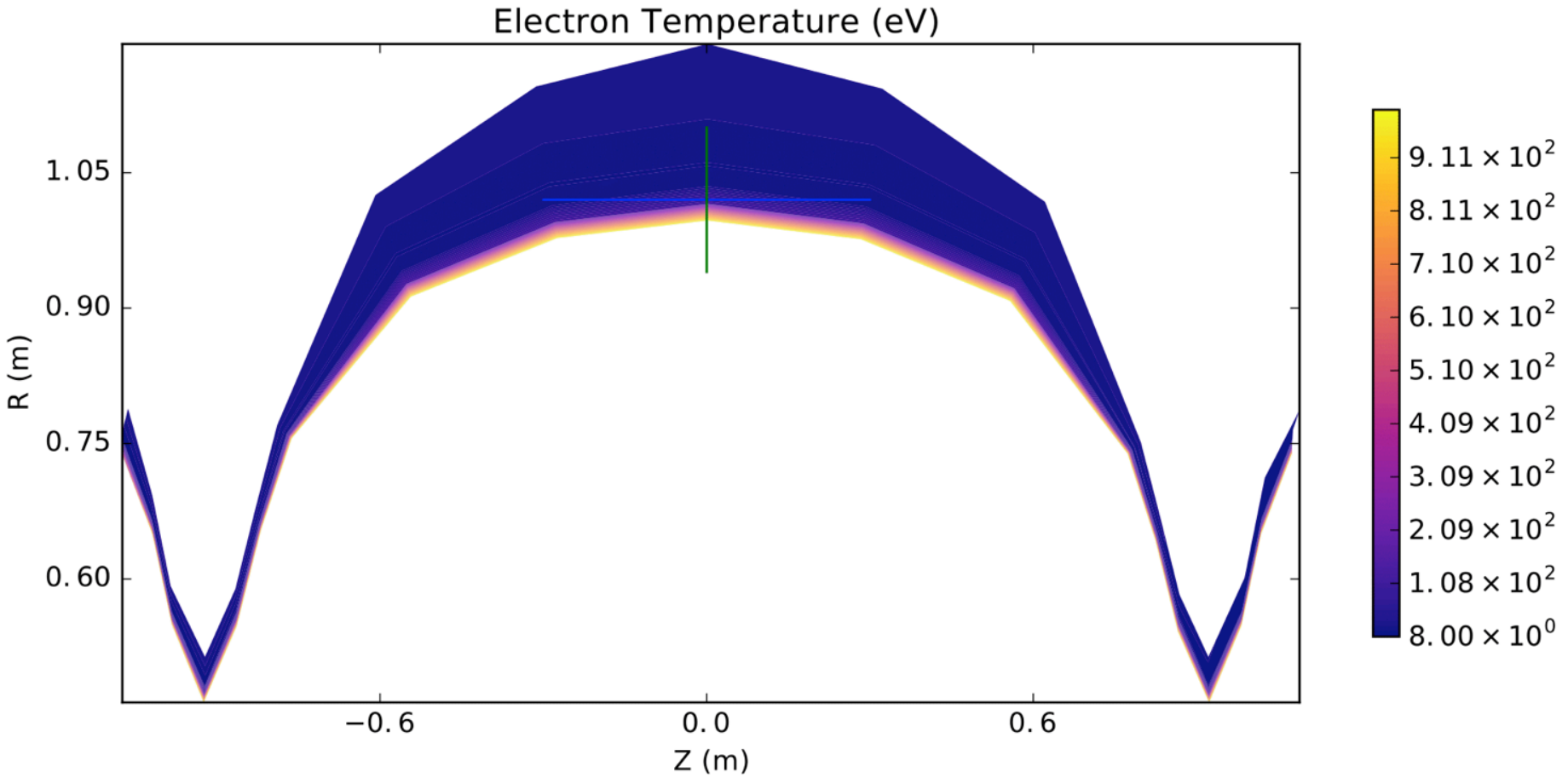
Flux boundary/Fixed boundary

High temperature and density

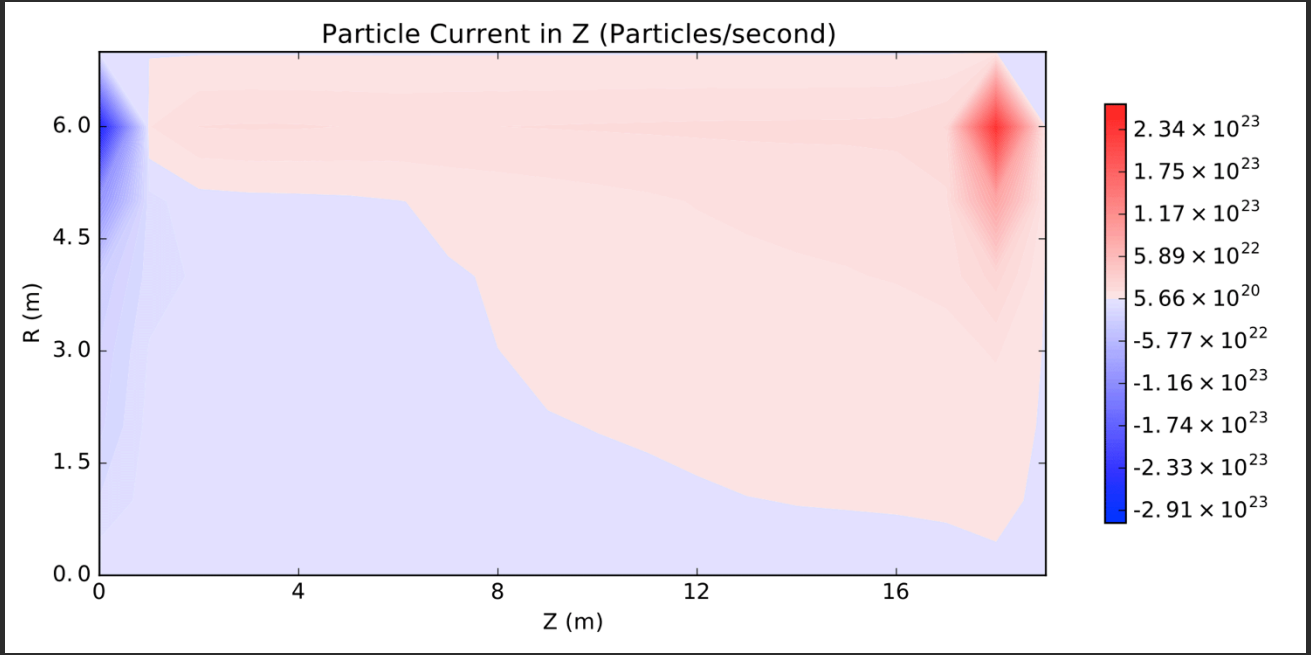
Inner/Outer gas wall

Power source

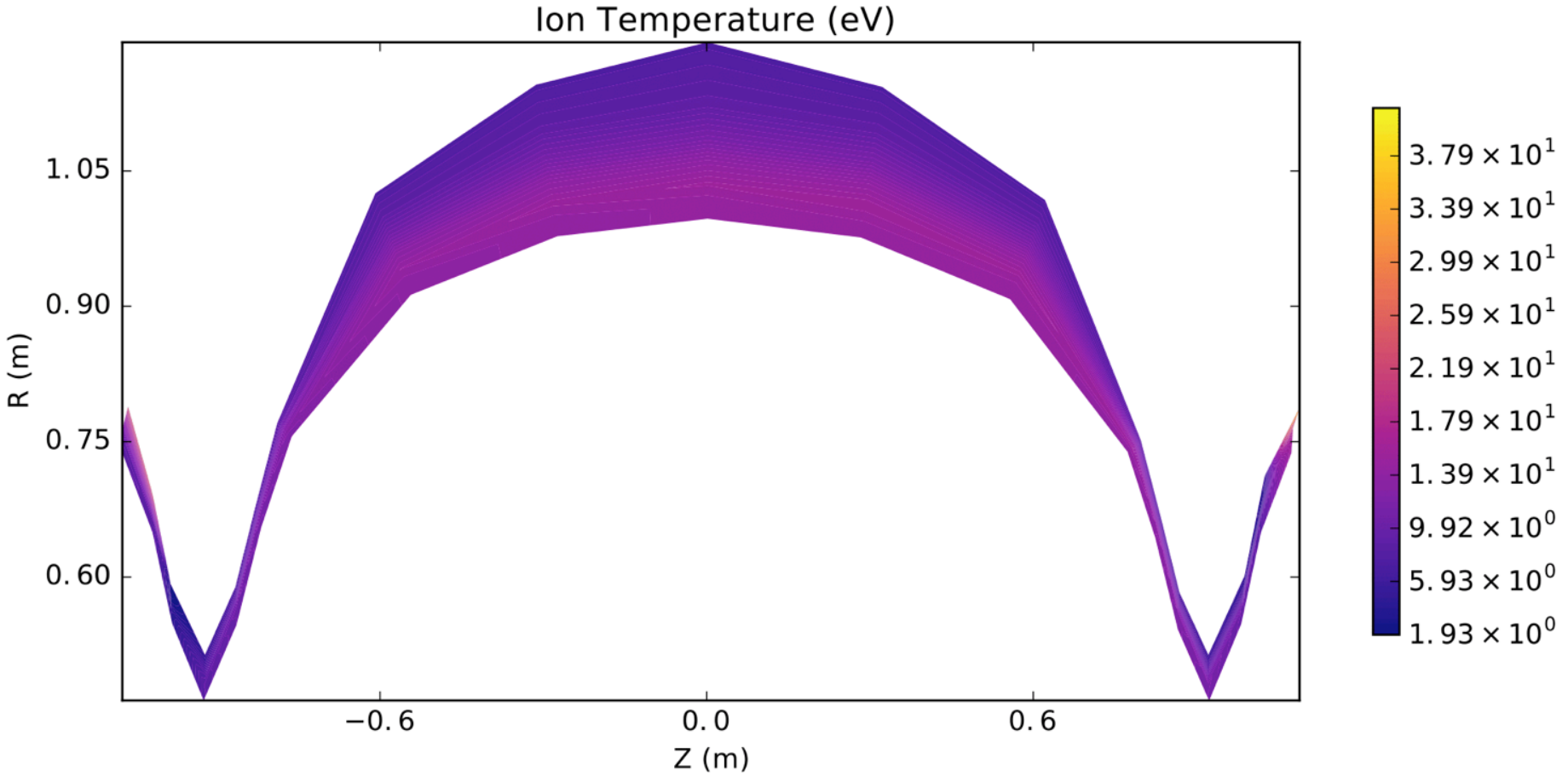
AlanFixedBoundary3MW2kA



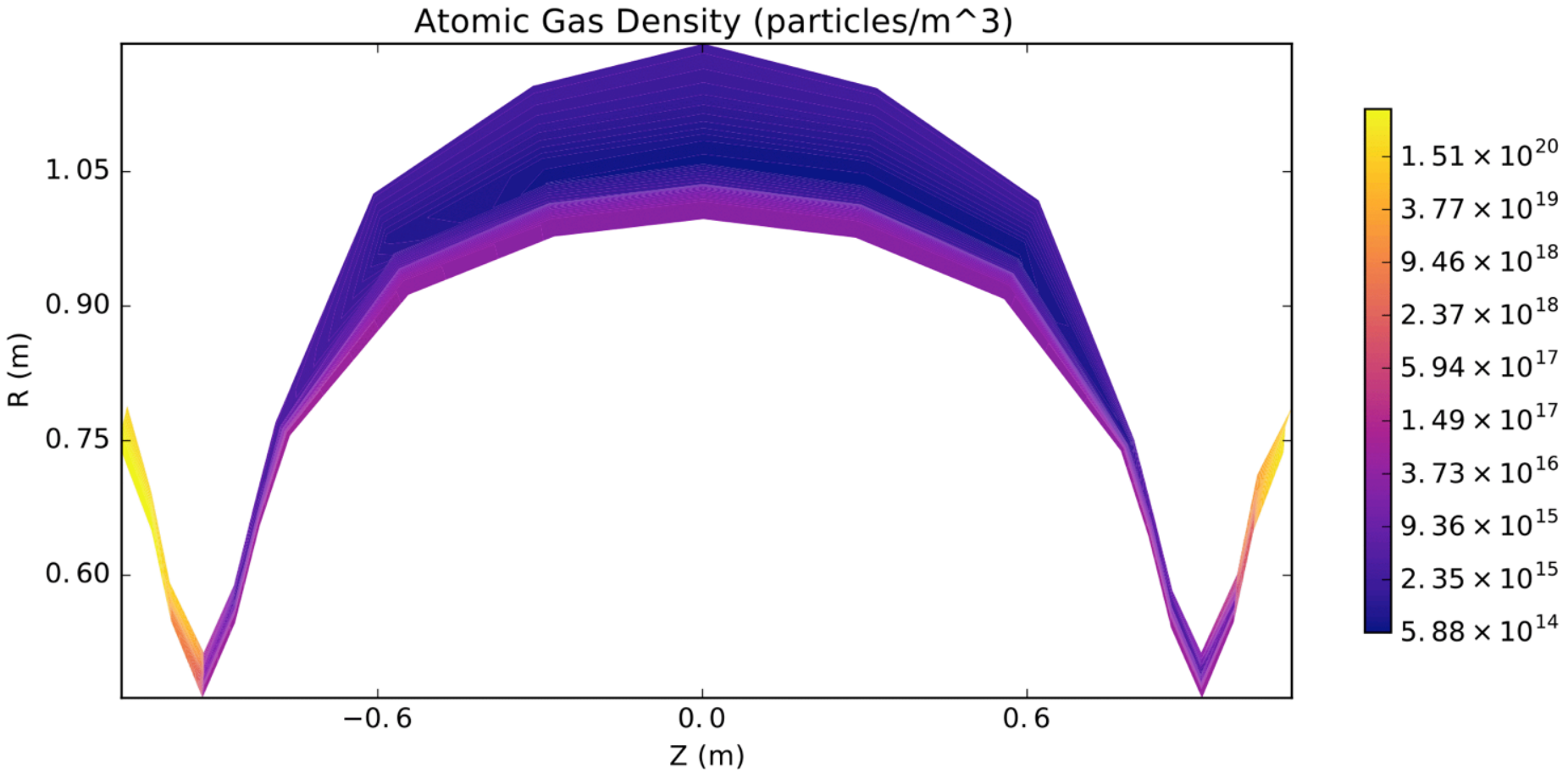
Alan2MWin90MWout



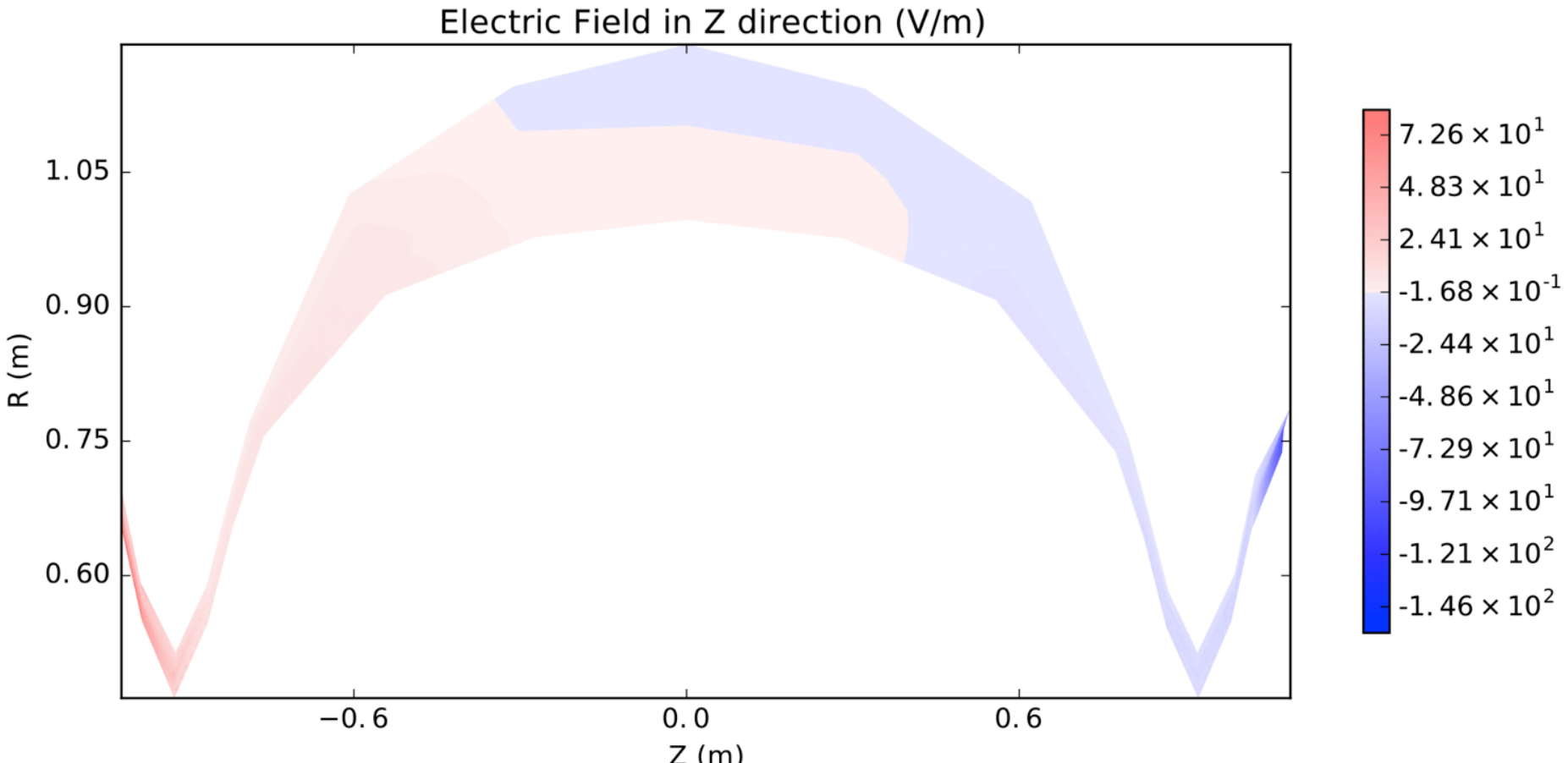
Alan1Source1Sink3MW2kA



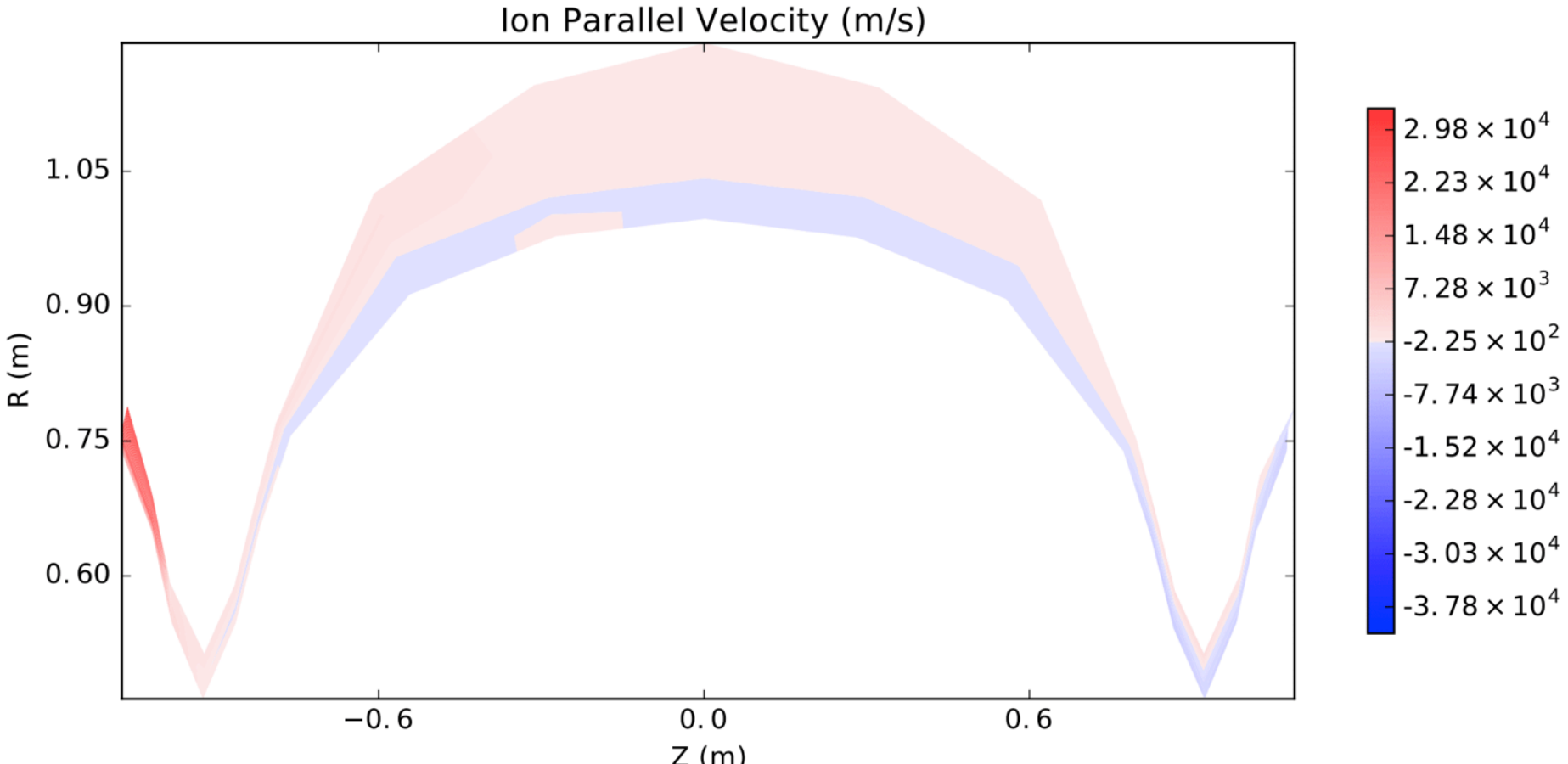
Alan1Source1Sink3MW2kA



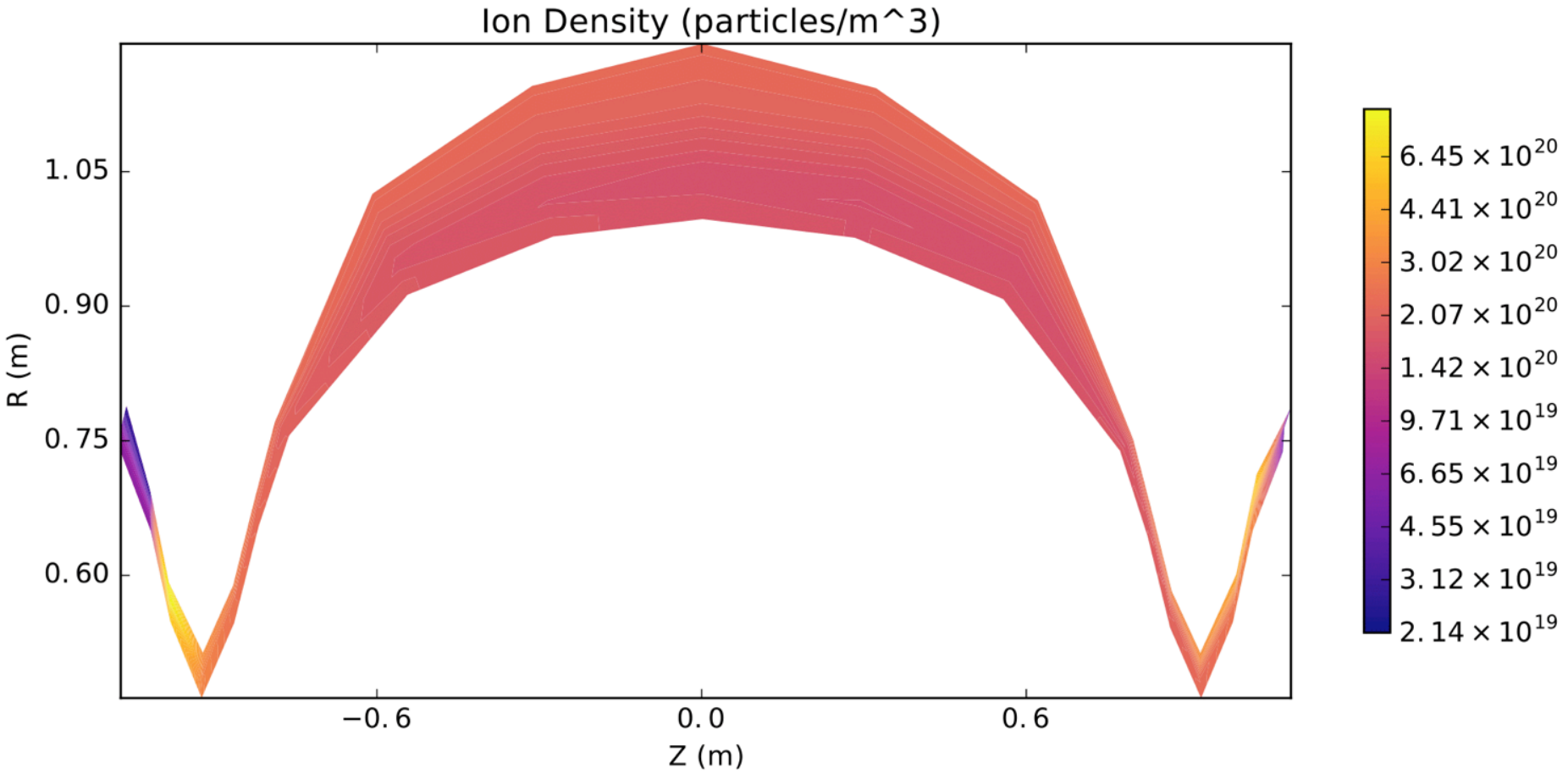
Alan1Source1Sink3MW2kA



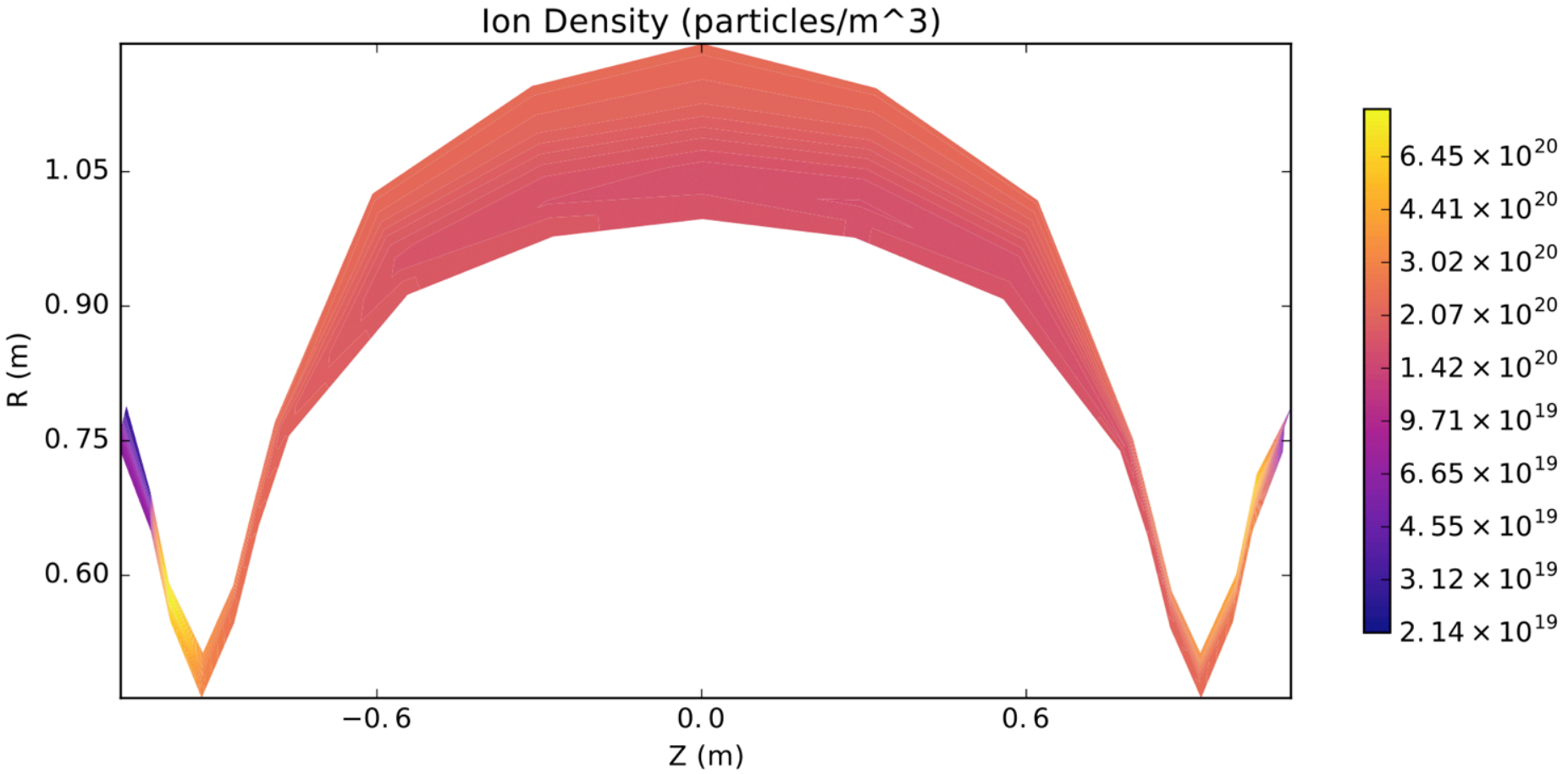
Alan1Source1Sink3MW2kA



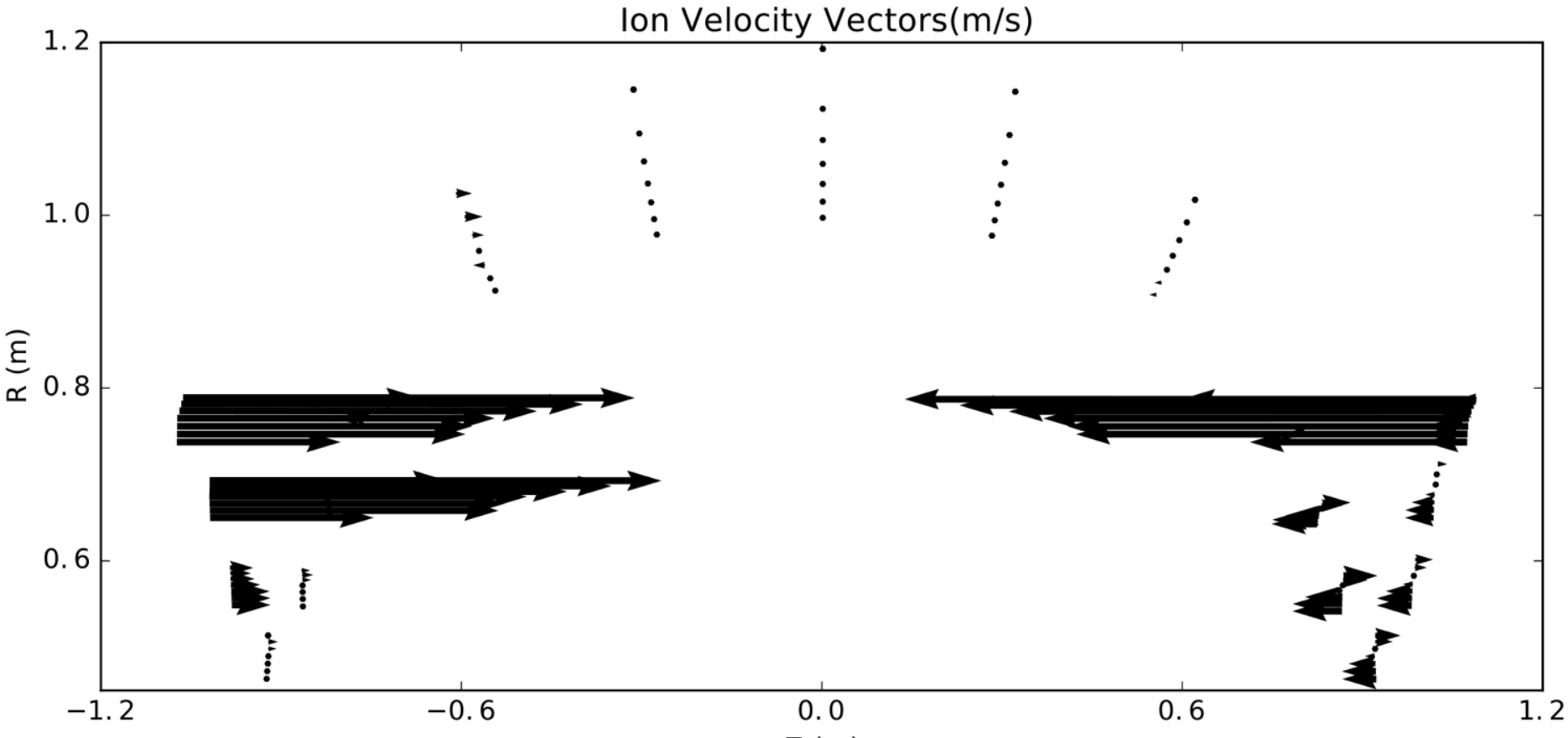
Alan1Source1Sink3MW2kA



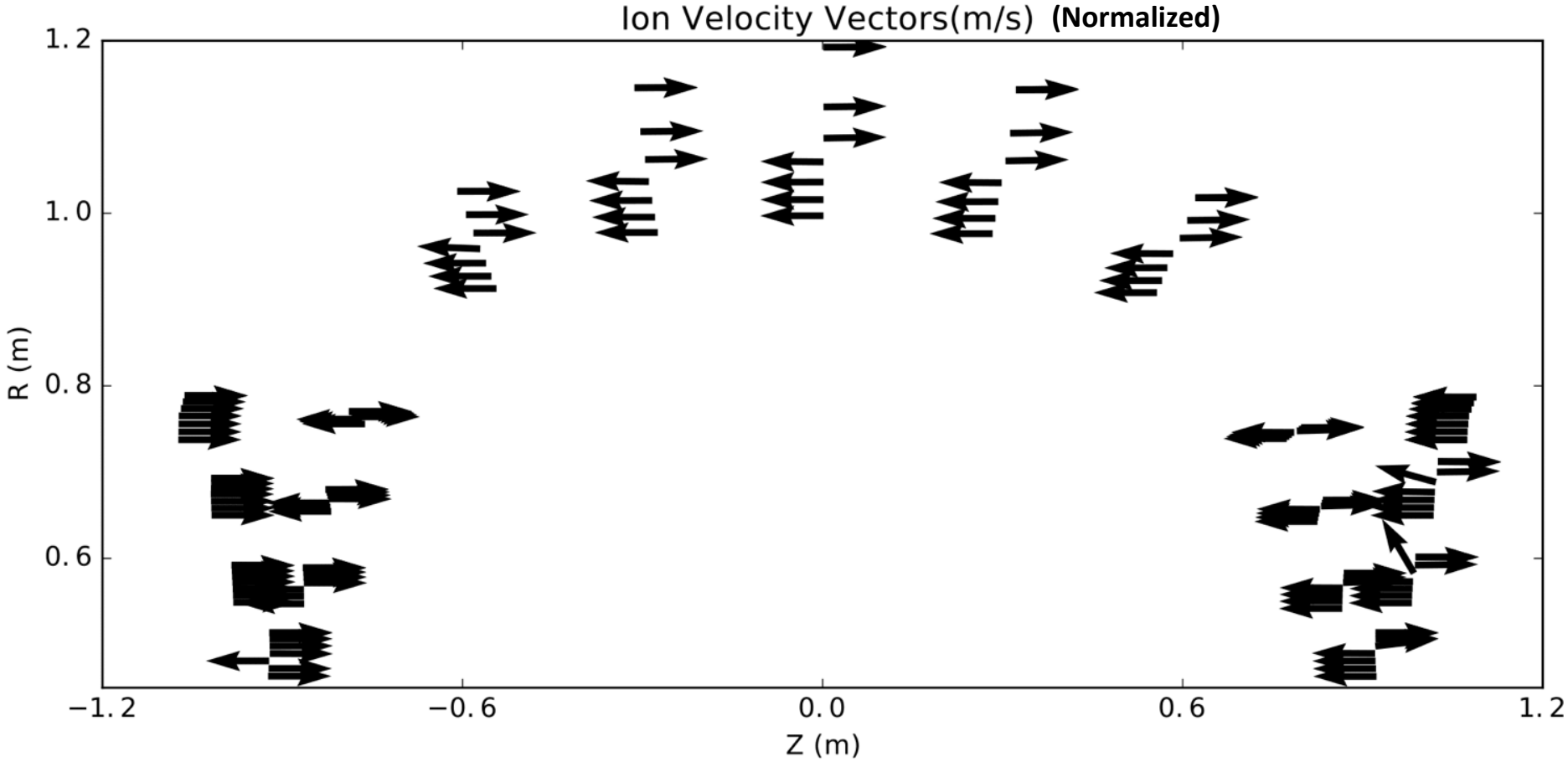
Alan1Source1Sink3MW2kA



Alan1Source1Sink3MW2kA



Alan1Source1Sink3MW2kA



Future

-Adding different gas species

-Changing strength of pump

-Continuing to examine the power balance

-Changing magnetic geometry

-Improving resolution

Impact

-Sparked interest in plasma physics and nuclear fusion

-Experience collaborating with well known researchers of the field

-Applied what I have learned in multiple fields to real life applications

Acknowledgements

-Eugene S. Evans

-Olivier Ozicard

-Tom Rognlien

-Alan Kaptanoglu

-Nick McGreivy

-Sam A. Cohen