Princeton Plasma Physics Laboratory

PPPL- 4773

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Plot/SurfW: Plotting Utility for EDGE2D Output

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June, 2012

PPPL PRINCETON PLASMA PHYSICS LABORATORY

Prepared for the U.S. Department of Energy under Contract DE-AC02-09CH11466.

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“PlotSurfW: Plotting Utility for EDGE2D Output”

by

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Feb. 21, 2012

Princeton Plasma Physics Laboratory

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1. INTRODUCTION

This report describes a utility that was developed to display EDGE2D results. The utility is focused on results that relate to impurity density, velocity, and particle fluxes in the SOL and divertor. Due to the complicated nature of 2D impurity sources, the concentration of the thermal force near the separatrix and near the divertor entrance, the impurity flow pattern and impurity densities are not necessarily easy to visualize. Thus, we wanted a utility that allowed simple and quick visualization of the impurity behavior. In order to achieve this we overlaid the divertor hardware for plots inside the divertor and we expanded the appearance of the main chamber SOL by plotting distance along the field lines vs. SOL depth with the density (or velocity or flux or other quantity) the false colour. Also, we allowed for the plotted variable to be a function of the other EDGE2D result variables.

This report is divided into the following sections. In section 2, we describe how to setup and use the utility, which we call “plotsurfw”. In section 3 are examples of plots of the impurity densities, the impurity particle velocities, and the impurity flux densities. These plots are for 3 EDGE2D runs: one where tungsten was puffed at the main chamber vessel inner mid-plane (there is no Be or sputtering in the calculation), another where there is only sputtered Be and W in the calculation, and the calculation time is between ELMs, and a 3rd which follows from the 2nd calculation but has been stopped in the middle of a 50 kJ ELM. The idea was to illustrate the impurity plotting ability of “plotsurfw” with a variety of plasma types.

PlotSurfW.pro was written by Bill Davis, following the specifications of Jim Strachan, PPPL, and was funded by the US DoE, through a budget under Randy Wilson’s oversight. Many thanks to Gerard Corrigan and Derek Harting at JET for help and advice. Please send comments and questions to bdavis@pppl.gov.

2. Setup and Operation of PLOTSURFW

The plotsurfw.pro IDL code displays a widget which helps you create surface and vector plots of output variables from the EDGE2D code run at JET (see Gerard.Corrigan@ccfe.ac.uk for more on EDGE2D). These are the important ideas about using “plotsrurfw”:

1. The following should be in everyone’s PATH, so type the following at the LINUX command line:

   `plotsurfw`

   This will set the appropriate environmental variables, invoke IDL and bring up the widget:

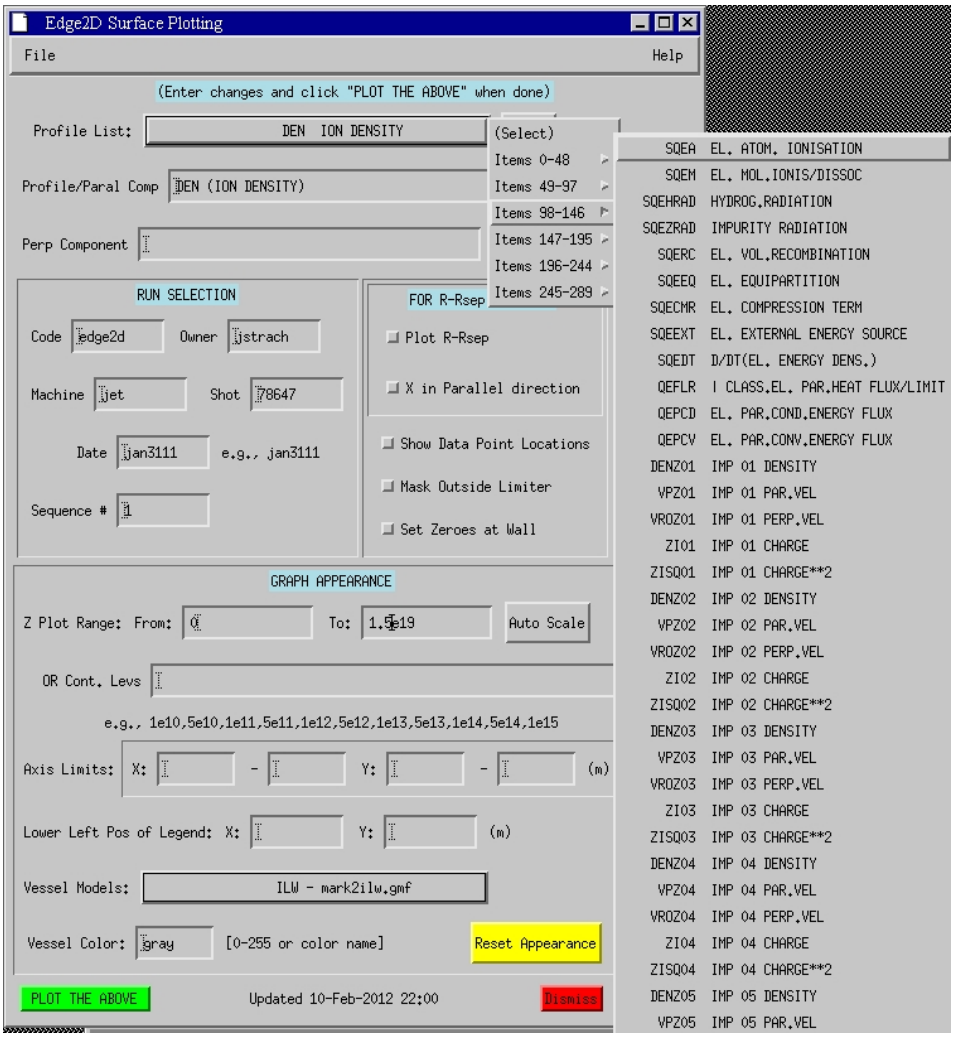


Fig. 1. Example of the Profile List Pull-down menu in PlotSurfW.pro showing some impurity profiles in the EDGE2D output file (the output from these settings is shown in Fig. 7).

2. You can select the variable to plot from the pull down menu in Fig. 1, or type the name directly in the Component field(s) below the pull-down menu. These variables come from the getdes command:

```
getdes -f[FILE] -m[MACHID] -o[OWNER]  <CODEID SHOTID DATEID SEQNUM>
```

The initial contents of the Profile List pull-down menu is based on the keywords specified when plotsurfw was invoked (not all items listed are appropriate for surface plotting). If changes are made in the "RUN SELECTION" section, you may click on "Update" to have the Profile List refreshed.

Whenever a getdes signal name has an underscore at the end, it means you append the impurity species index (1 or 2) to get the signal for that impurity, e.g.,

DENZT_1 is the first impurity species total density (Tungsten in the case above)

DENZT_2 is the second impurity species total density (Beryllium)

A short list of profile names is displayed by selecting "Interesting Profiles" under the Help menu.

3. If two "profiles" are specified in the top two fields in the widget (in "Profile/Paral Comp" and "Perp Component"), vector plots, like those from the earlier plotvect code, are produced instead. For example, VPI and VRO are parallel and perpendicular ion velocities, respectively, illustrated in Fig. 2. The second field in the widget for "Z Plot Range" can be used to set the value for the arrow length shown in the legend.

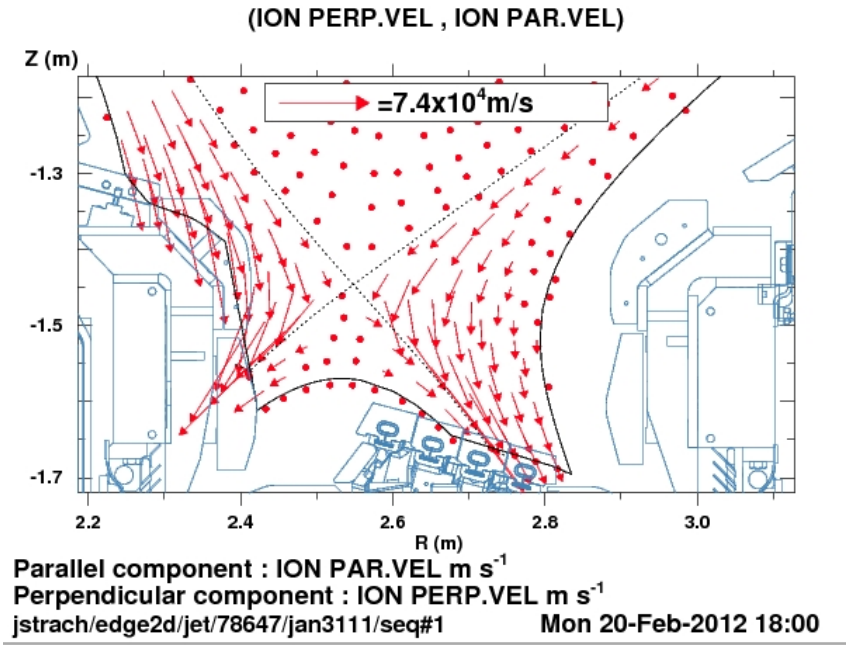


Fig. 2. Example of Ion Velocity Vectors from EDGE2D output for JET shot 78647.

4. You may also plot numerical combinations of signals by entering strings like:

```
3.4e13*Tev^2/(Den*15)
```

The only operators accepted in such equations are +,-,/,* and ^ (exponent). NOTE that blanks are not allowed in these equations. See Figs. 3 & 4 for the widget and results.

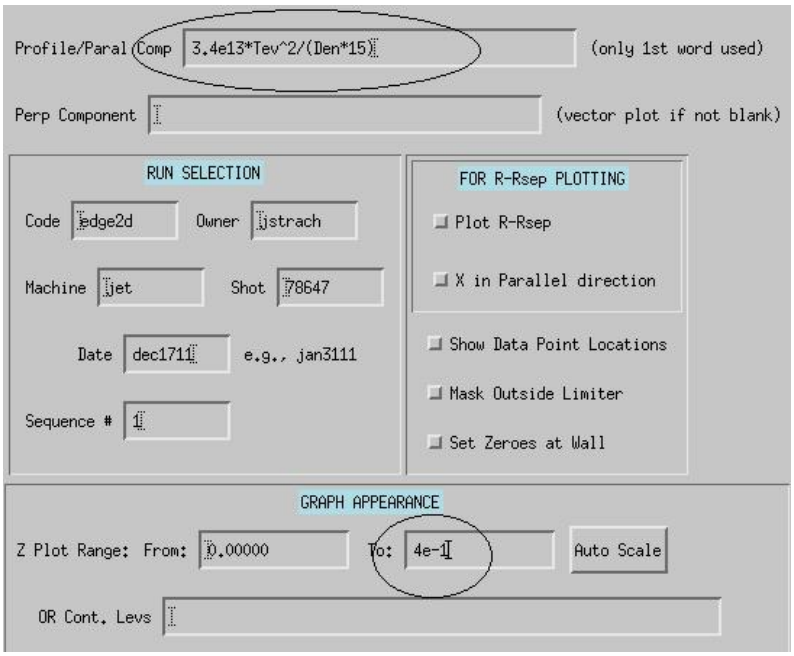


Fig. 3. Partial screen shot from PlotSurfW.pro showing how to get a plot of the Mean Free Paths of Ions, shown in Fig. 4.

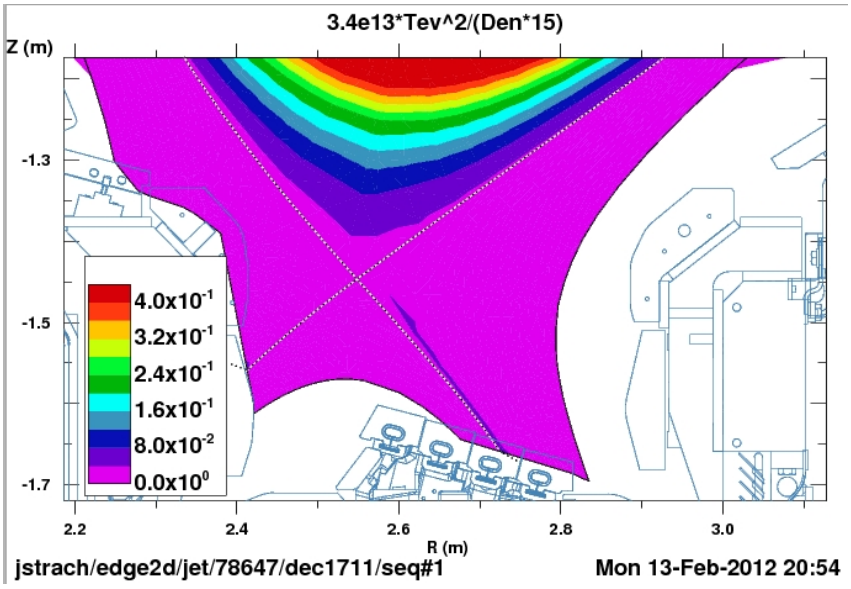


Fig. 4. Sample plot from PlotSurfW.pro from a calculation using 2 profiles (showing the Mean Free Path of ions).

5. By default the data is plotted vs. major radius (R) and height (Z) in the divertor region. If "Plot R-Rsep" is checked, the vertical scale is the distance from the separatrix (along a row) and the horizontal scale is the distance along a ring. Data for the entire main chamber is plotted by default with this option.

6. The IDL contour routine for irregularly-spaced data sometimes gives undesired (wrong) results when plotting across large areas with no data. The check boxes "Mask Outside Limiter" and "Set Zeroes at Wall" may eliminate these artifacts.

7. You can effectively produce log plots of the data by specifying logarithmic contour levels, such as 1e10, 3e10, 1e11, 3e11, 1e12, etc. See Fig. 5 and the output in Fig. 6. (A future version may have log plot controls.)

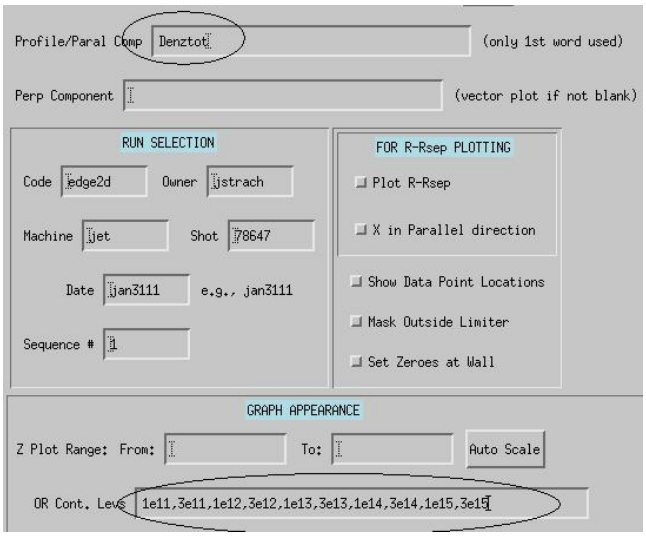


Fig. 5. Example of making a "**log**" plot of densities by specifying contour values.

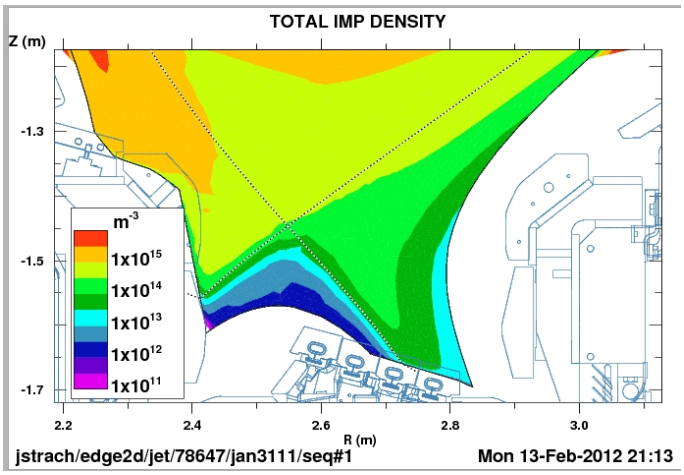


Fig. 6. Sample output from the settings shown in Fig. 5, effectively plotting **log** values by specifying logarithmic contour intervals.

8. The plot legend for surface plots in the divertor region is placed by default on the lower left of the surface plot, but it may overlay data when zooming in. You can change this position by entering the desired data coordinates for the lower left of the legend box.

9. Selecting a Vessel Model causes outlines of vessel components to be drawn. Thos available are listed in the drop down box. The color of this schematic may be changed by entering a number representing an index in the IDL color table 5, or by entering certain color names, like brown, red, ltgreen, yellow, etc.

10. The "Updated..." string at the bottom of the PlotSurfW widget tells you the last time a routine was changed in the default IDL directory for the code. To find the directory of an IDL routine, do something like:

```
IDL> doc_library,'plotsurfw'
```

11. The output from plotsurfw is postscript files managed by the XPC List Box, illustrated in Fig. 7 (see it's help for more on how it works).

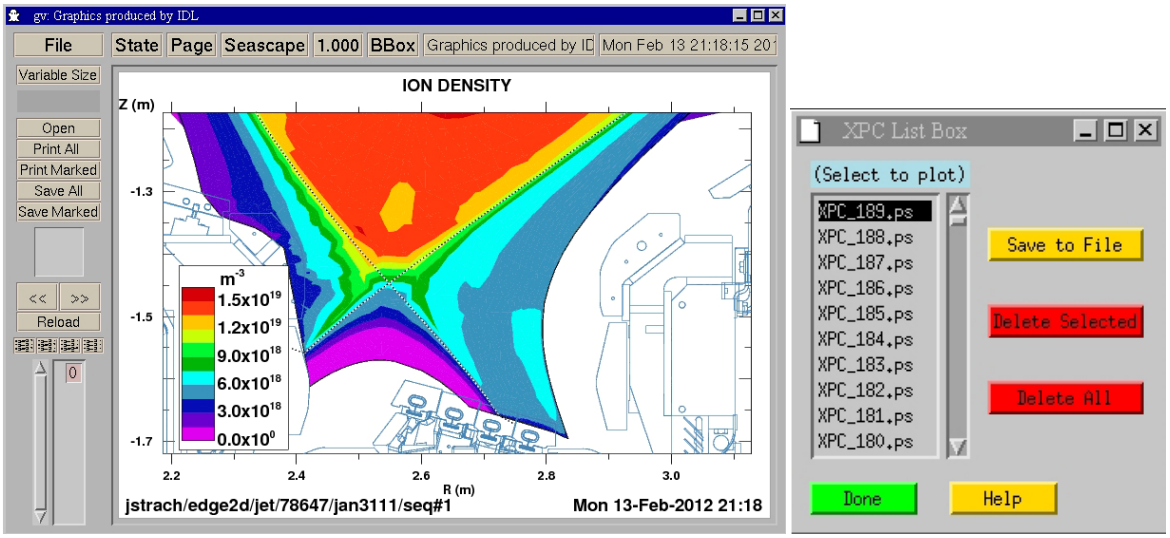


Fig. 7. Screen shot of the XPC List Box and the graphical output in the gv utility.

The plots are displayed by gv, which is initiated if it is not running. It refreshes itself when the contents of the file it is displaying changes. The refresh rate of gv can be set with an entry in your ~/.Xresources file using the gv.watchFileFrequency variable.

You can plot and save files from the gv interface. If you want to look at previous files, click on a lower name in the XPC List Box. Note that these files persist forever (up to 999 of them) until you manually delete them.

12. To generate plots without using a widget, see
/u/sim/eproc/default/plotsurfw/edge2dplus/batchsurf.pro and batchvect.pro.

3. CASE STUDIES

The following sample plots are for 3 cases, for JET, shot 78647:

1) Puffing case (jan3111#1) with tungsten being puffed from the inner wall,

2) ELM case (jan0312#4), with beryllium and tungsten arising from sputtering from the JET ILW, and

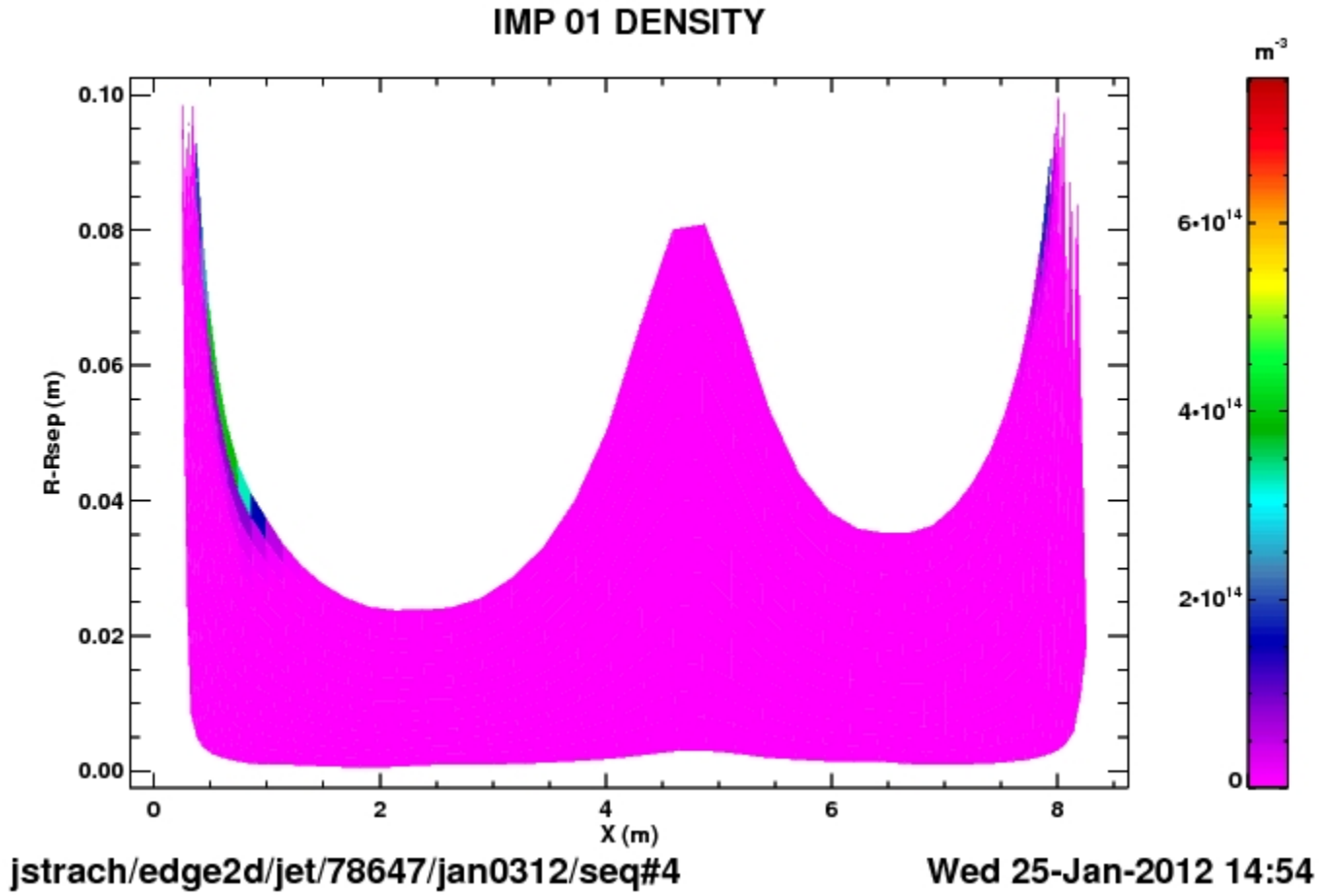
3) Between ELMs case (dec1711#1), with both beryllium and tungsten arising from sputtering from the JET ILW.

For each case, we then plot the density of each charge state, the velocity, and the particle flux density. These quantities are plotted in both a) the Main Chamber and b) the divertor region. The sequence of the impurity charge states being plotted are:

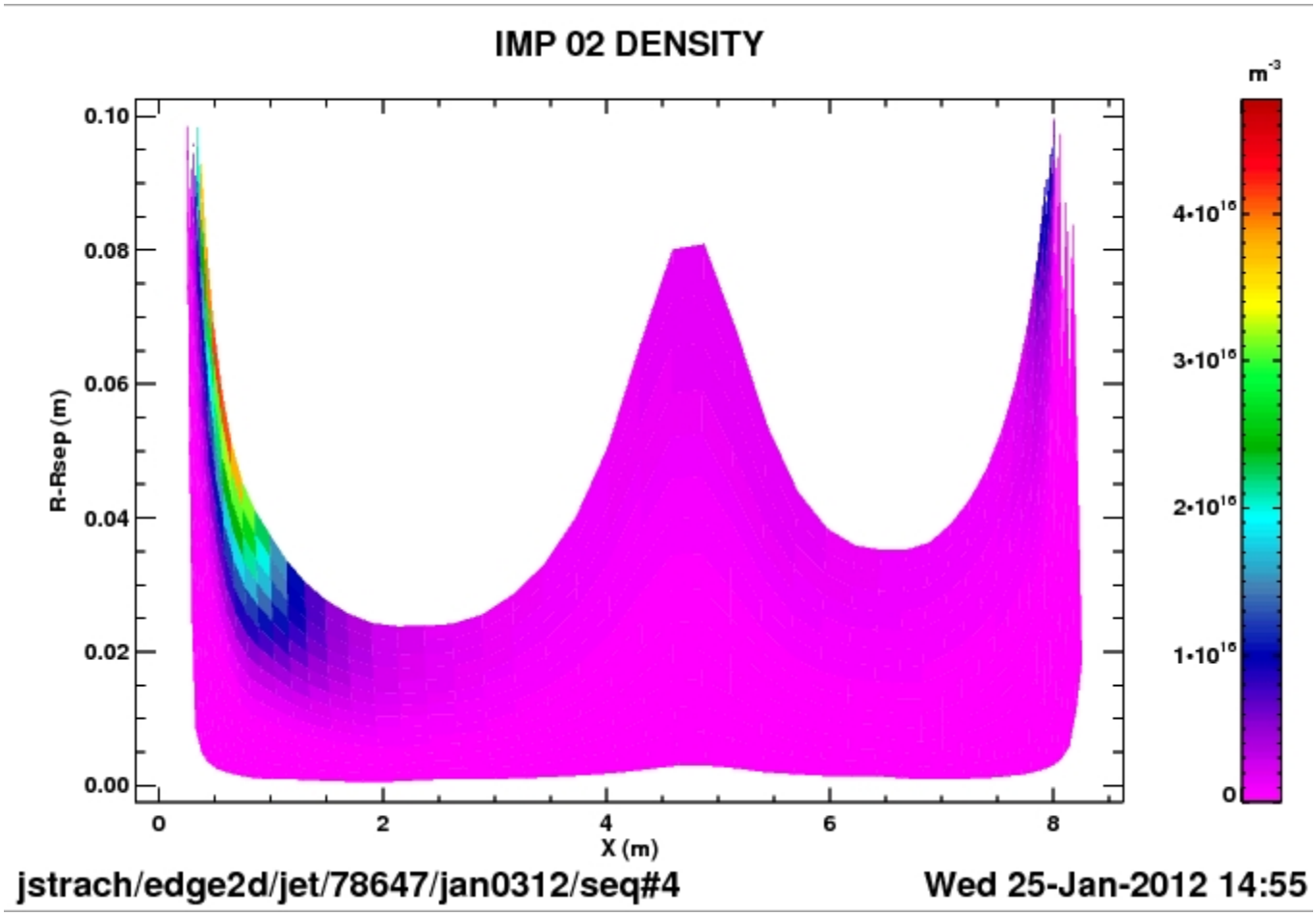
1) Tungsten charge state 1
2) Tungsten super stage W 2+ to W 6+
3) Tungsten super stage W7+ to W12+
4) Tungsten super stage W13+ to W22+
5) Tungsten super stage W23+ to W 73+
6) Tungsten charge state 74+
7) Beryllium +
8) Beryllium 2+
9) Beryllium 3+
10) Beryllium 4+

For comparison, the density, velocity and particle flux of deuterium is also shown.

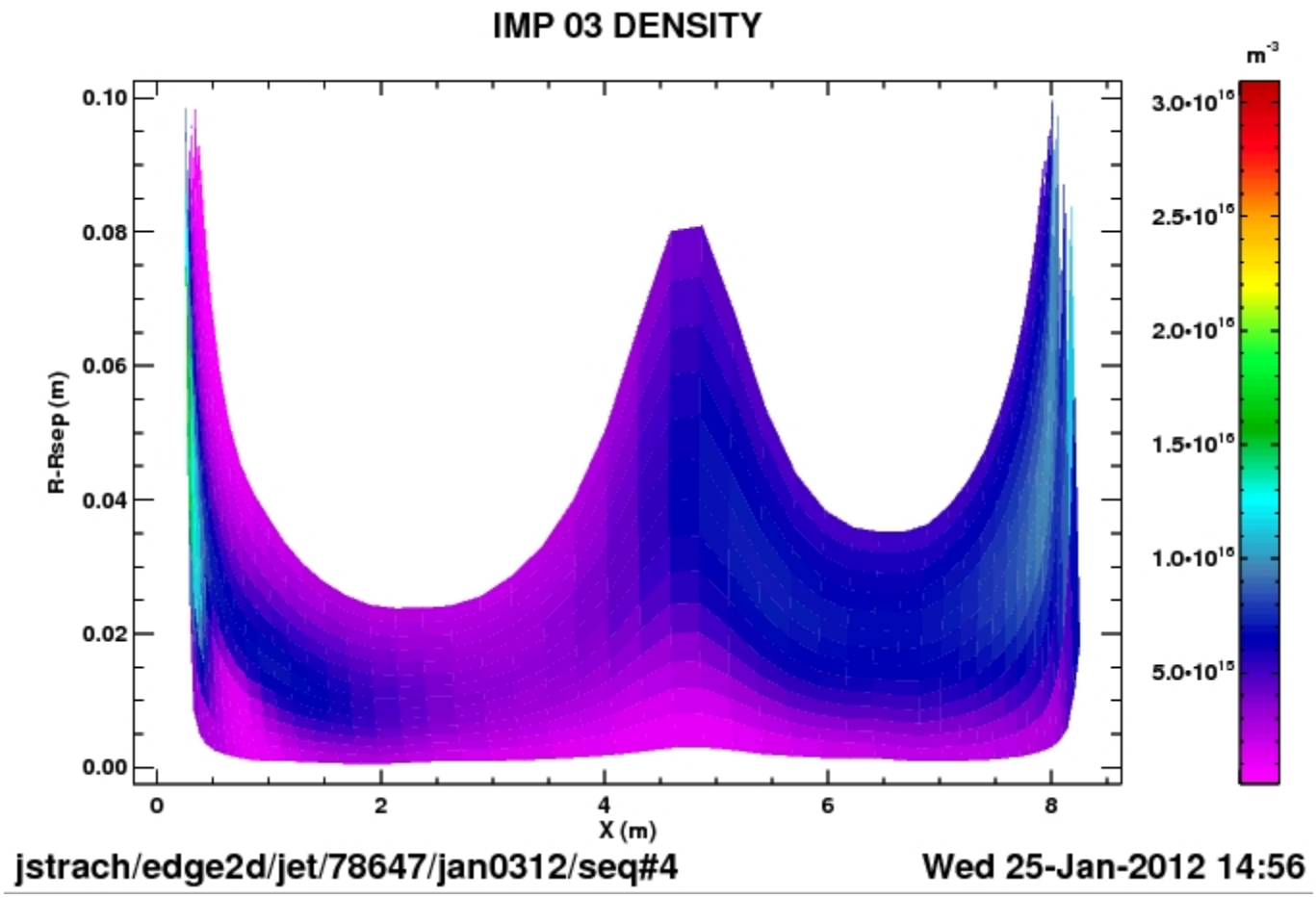
During an ELM: Impurity densities, main chamber view.



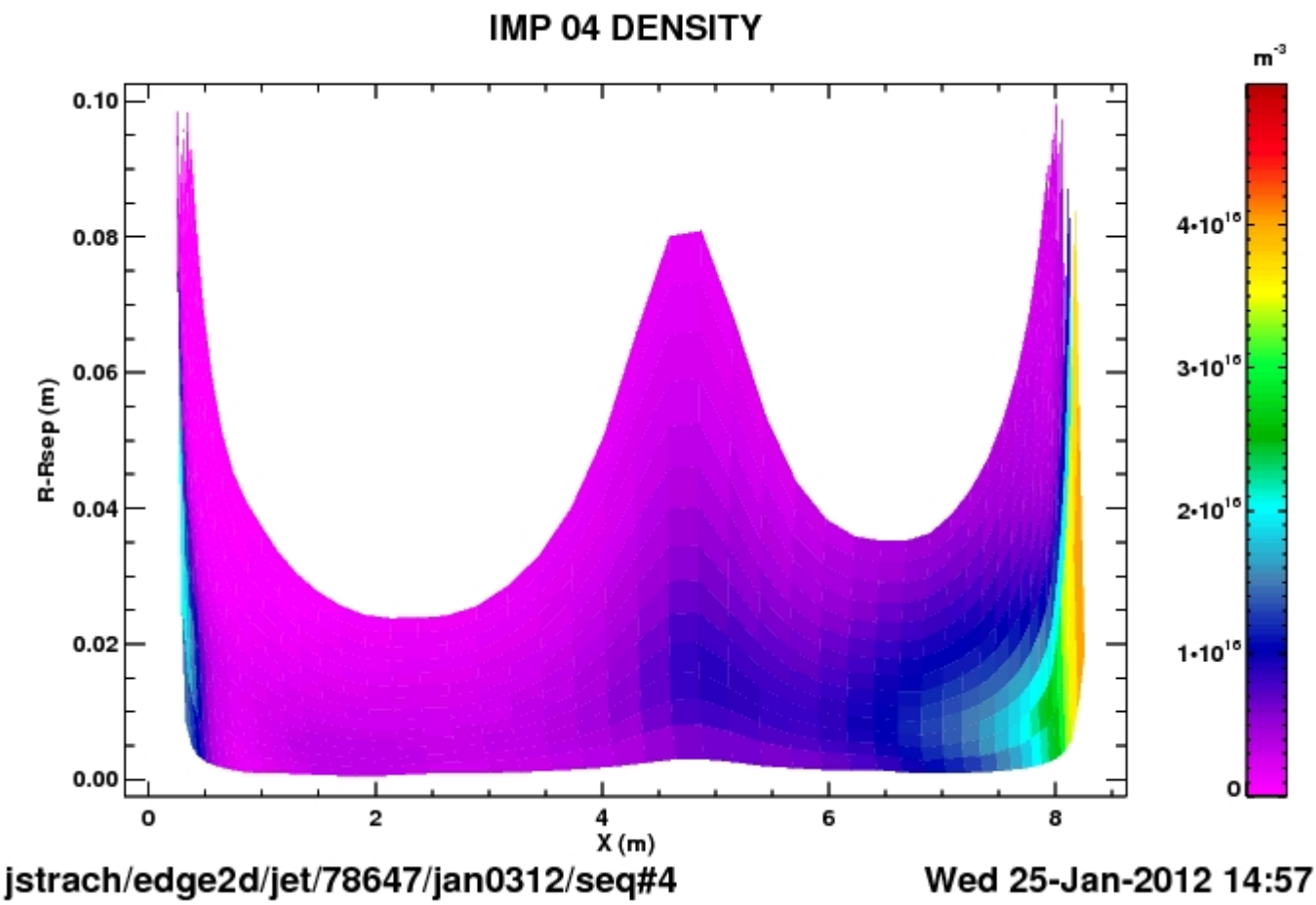
W^+ during an ELM



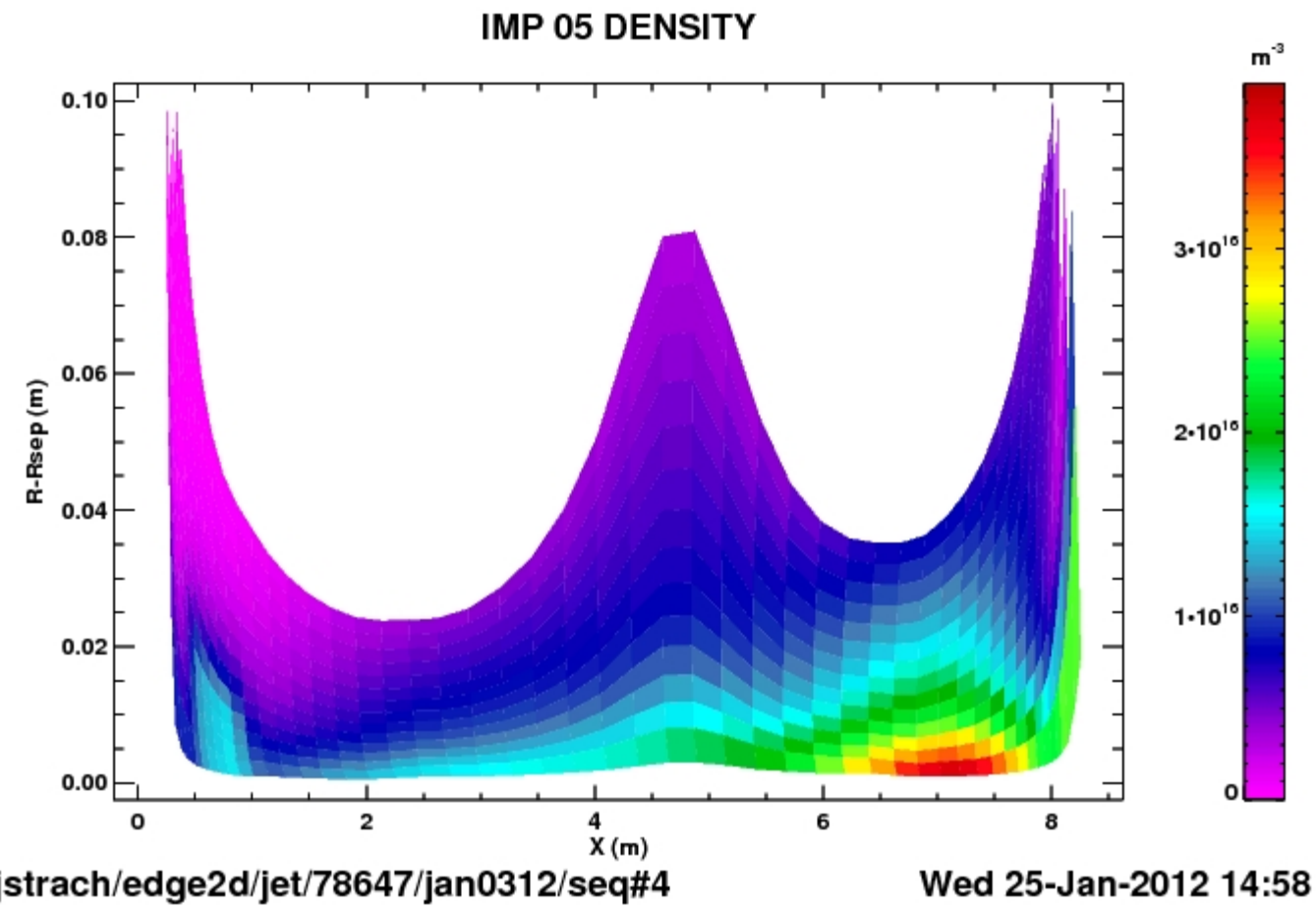
$W^{2+ \rightarrow 6+}$ during an ELM



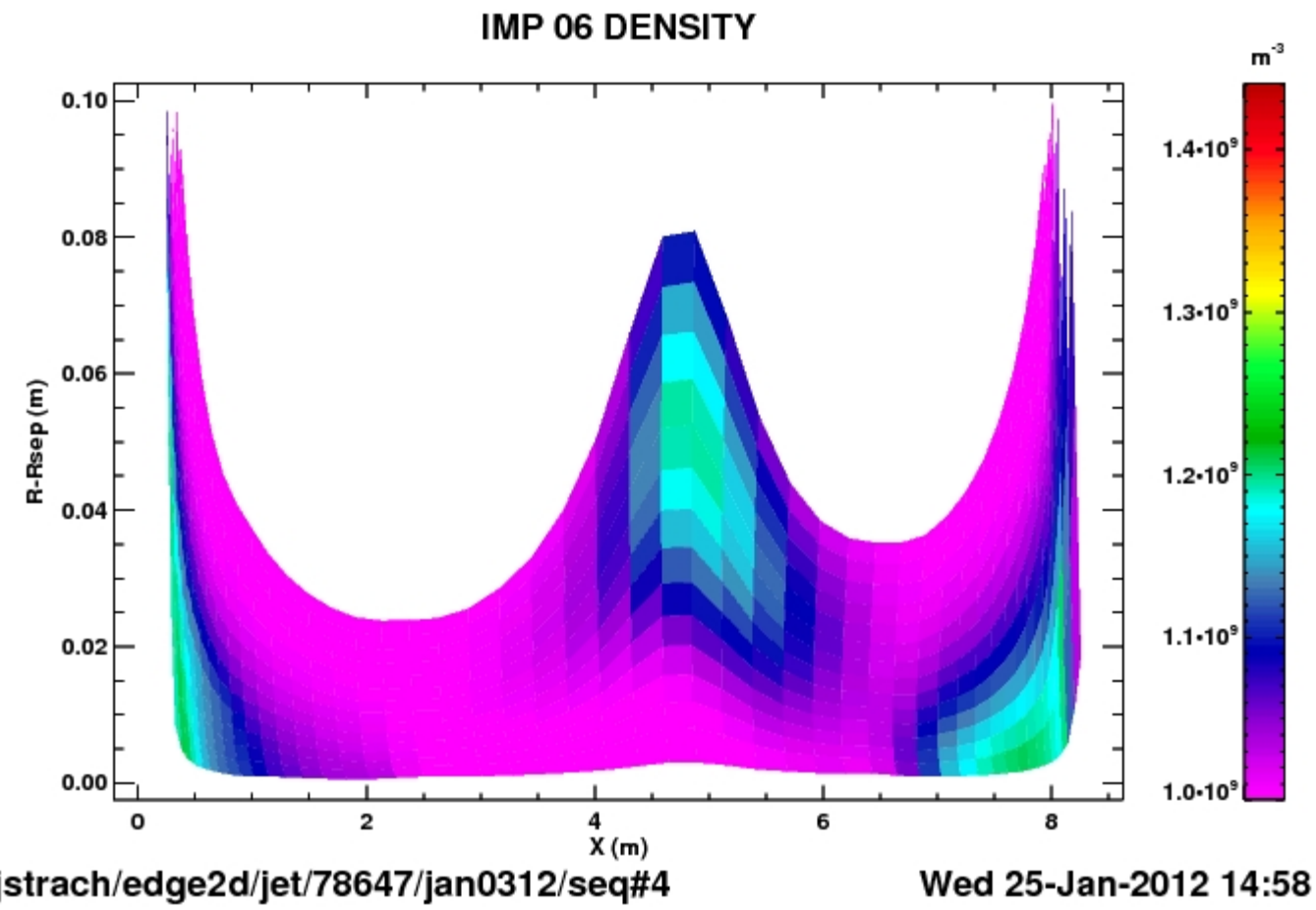
$W^{7+ \rightarrow 12+}$ during an ELM



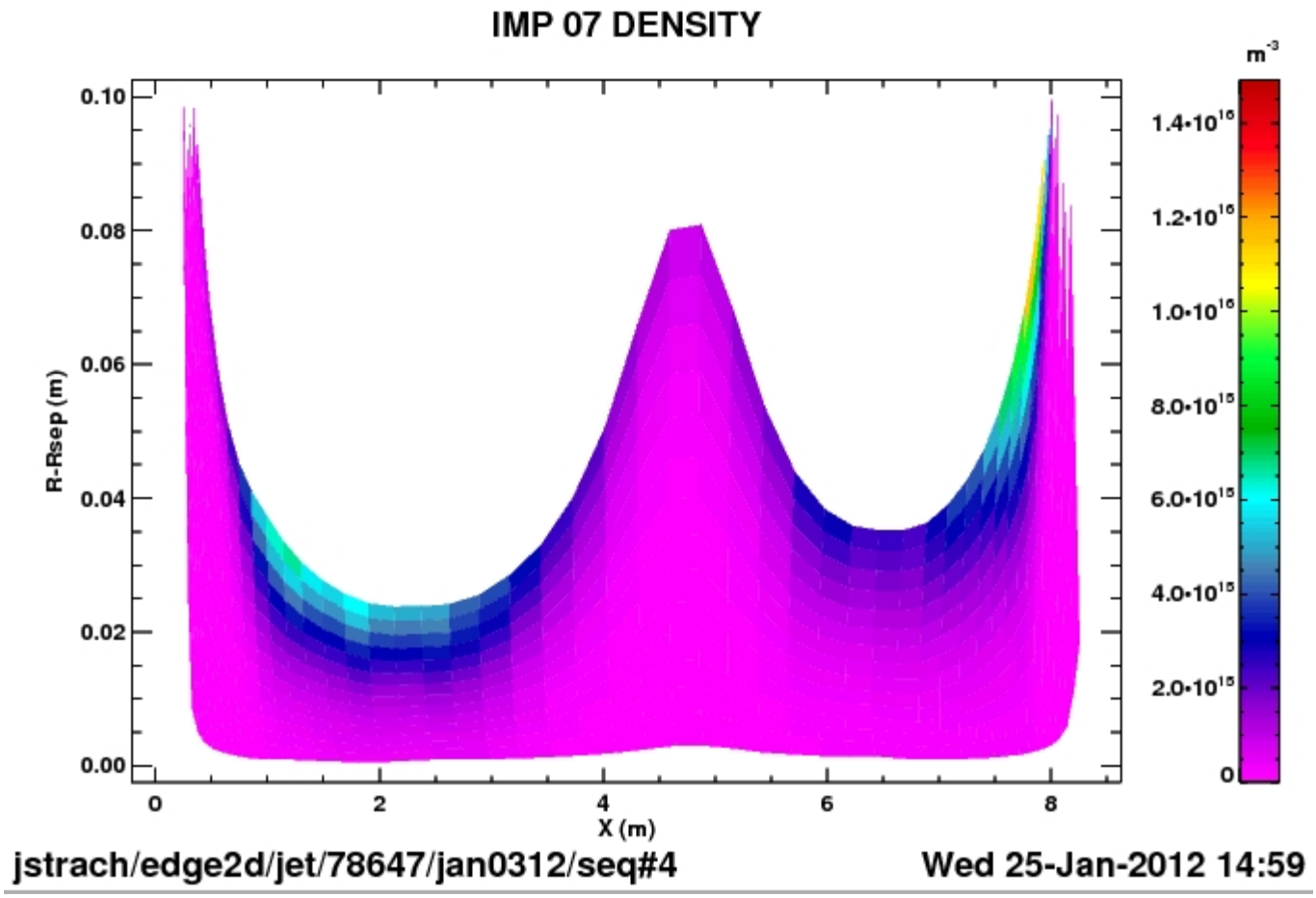
W bundle $^{13+ \rightarrow 22+}$ during an ELM



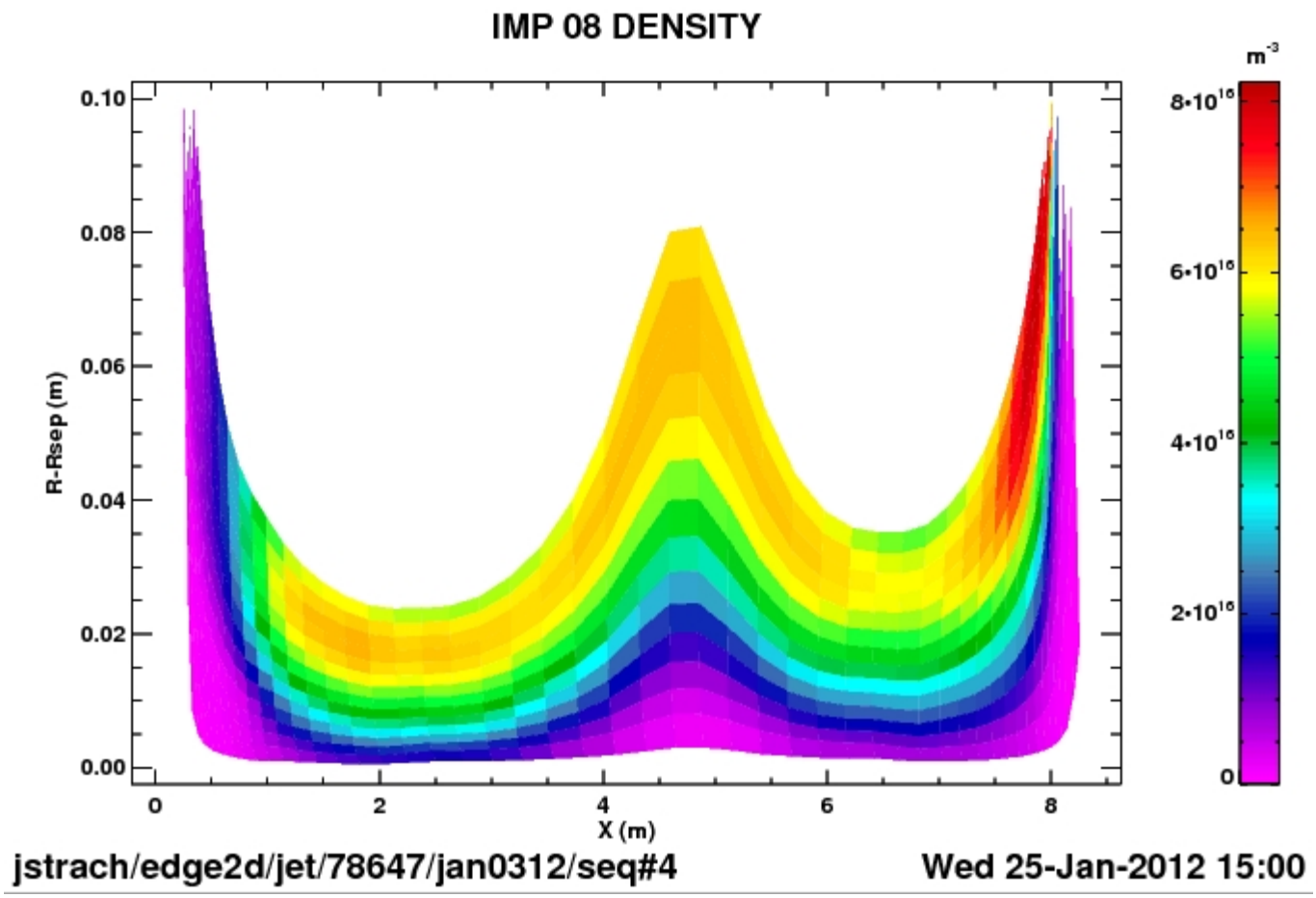
$W^{23+ \rightarrow 73+}$ during an ELM



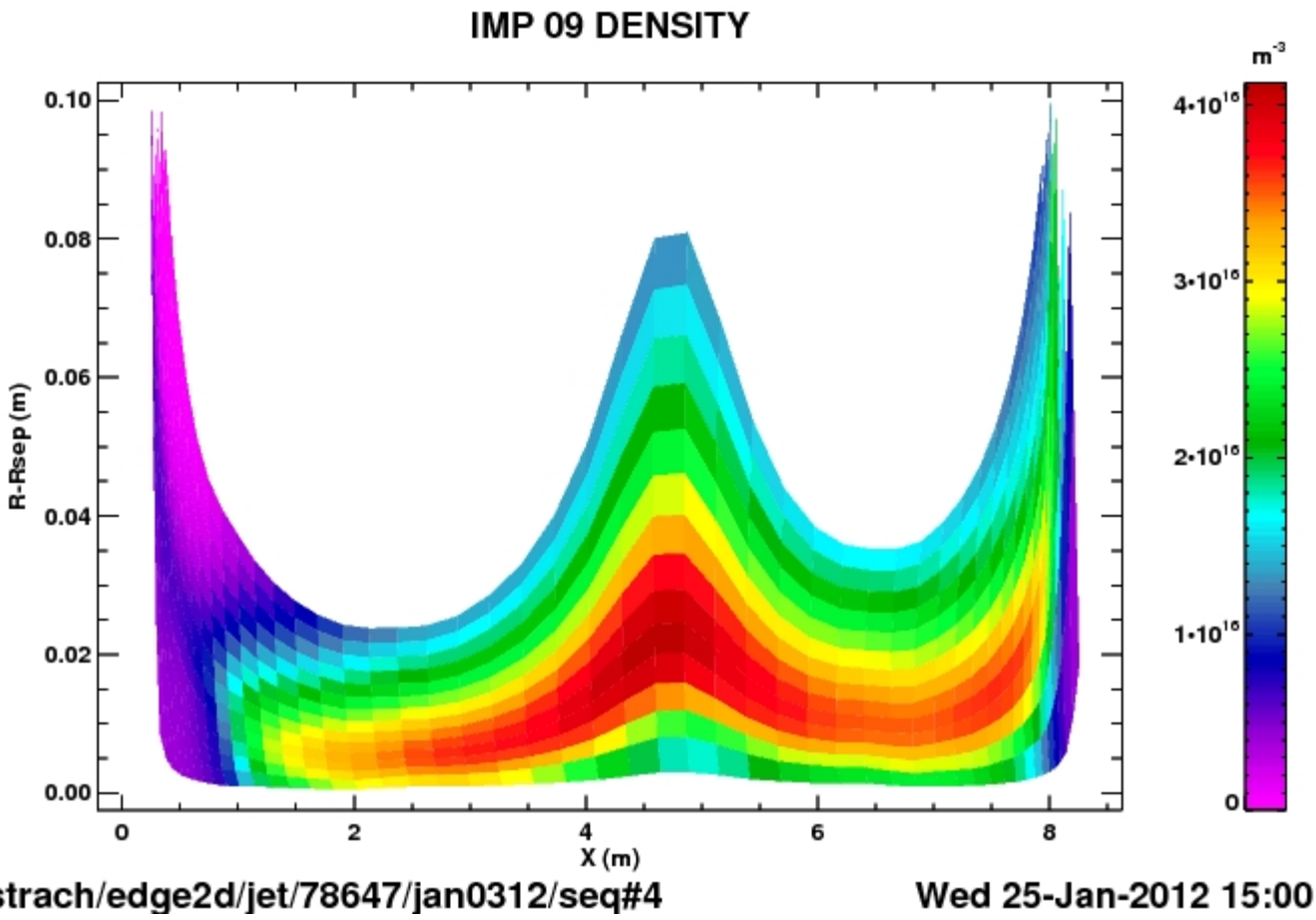
W^{74+} during an ELM



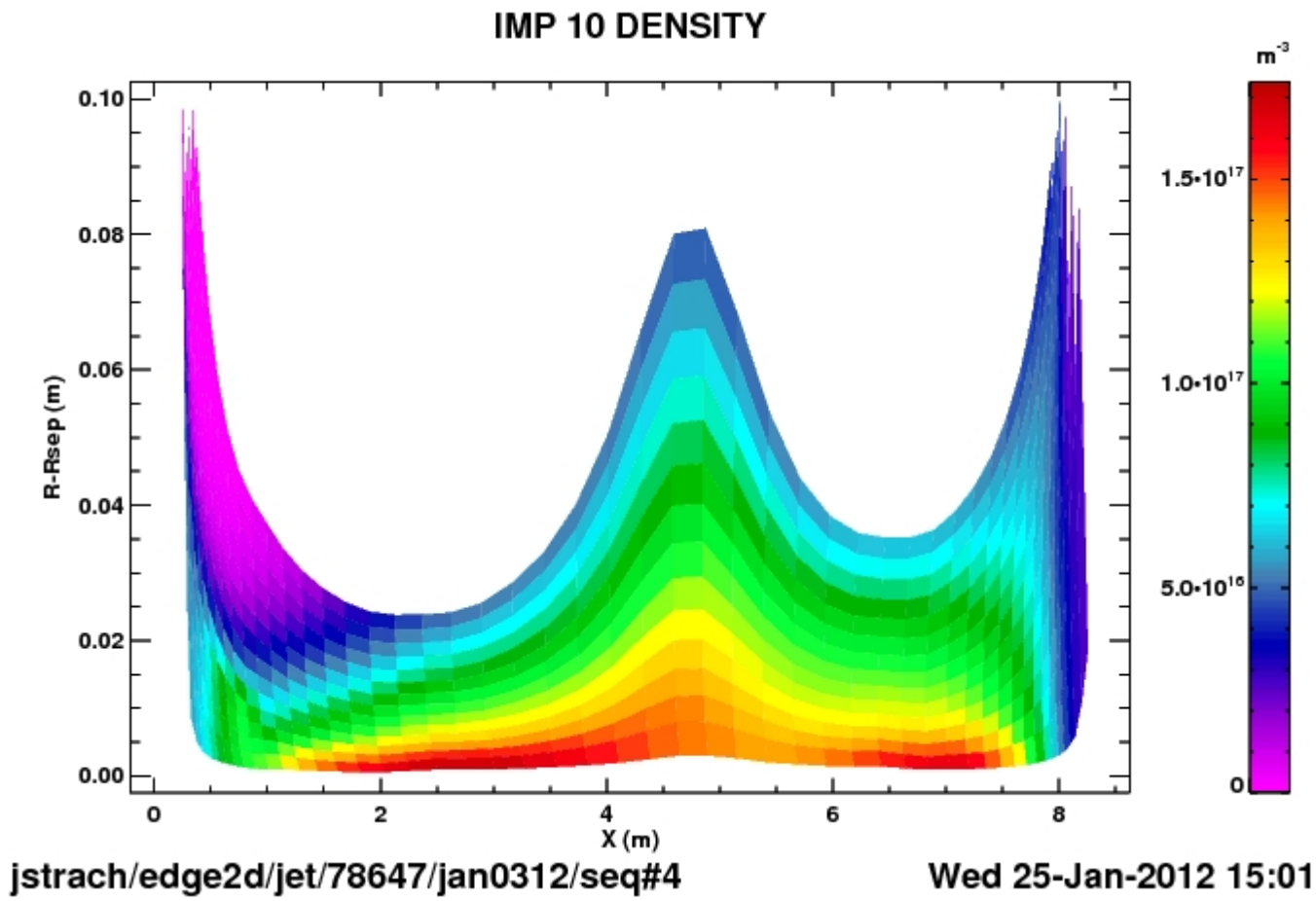
Be 1^{+} during an ELM



Be 2^{+} during an ELM

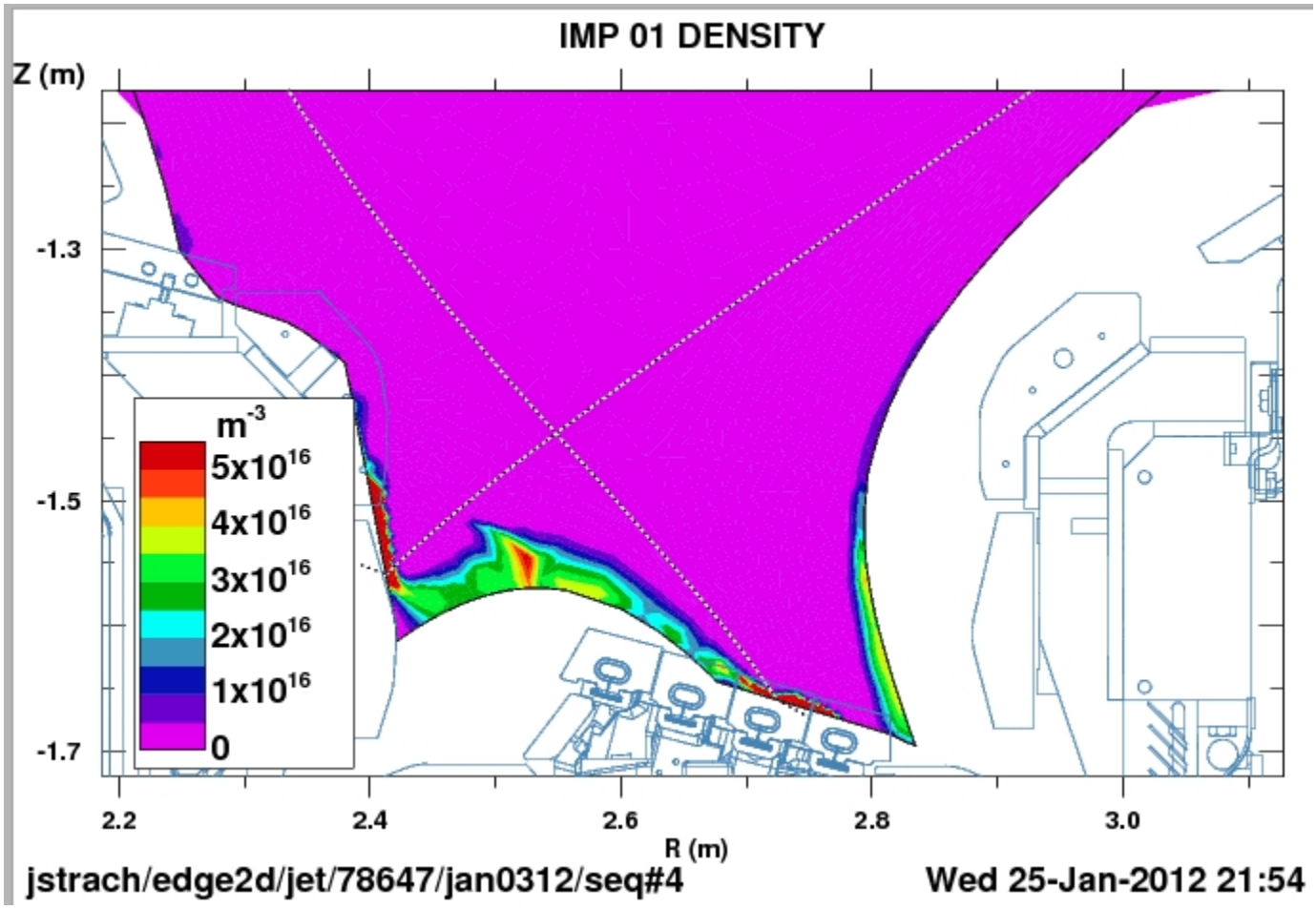


Be 3^{+} during an ELM

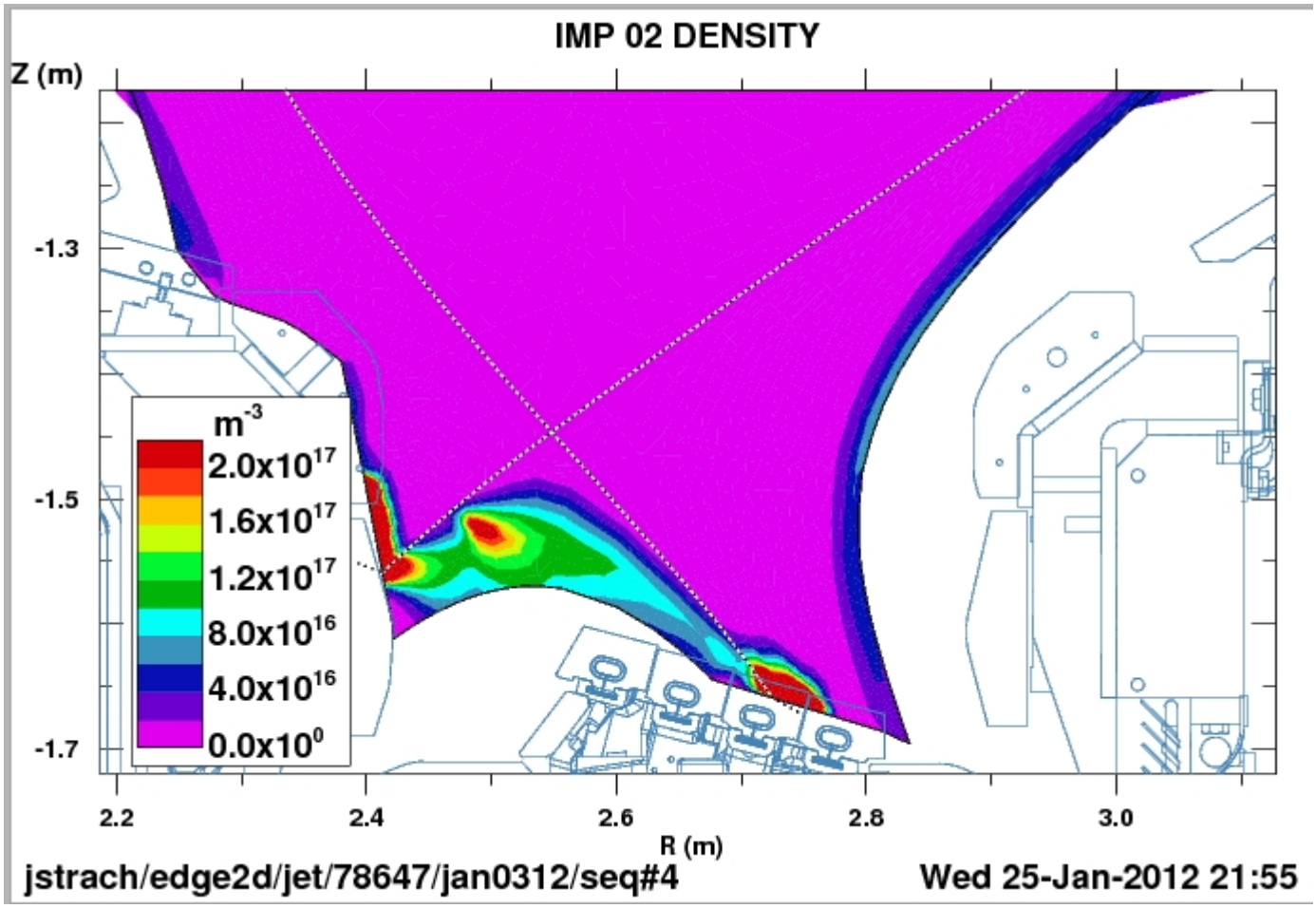


Be 4^{+} during an ELM

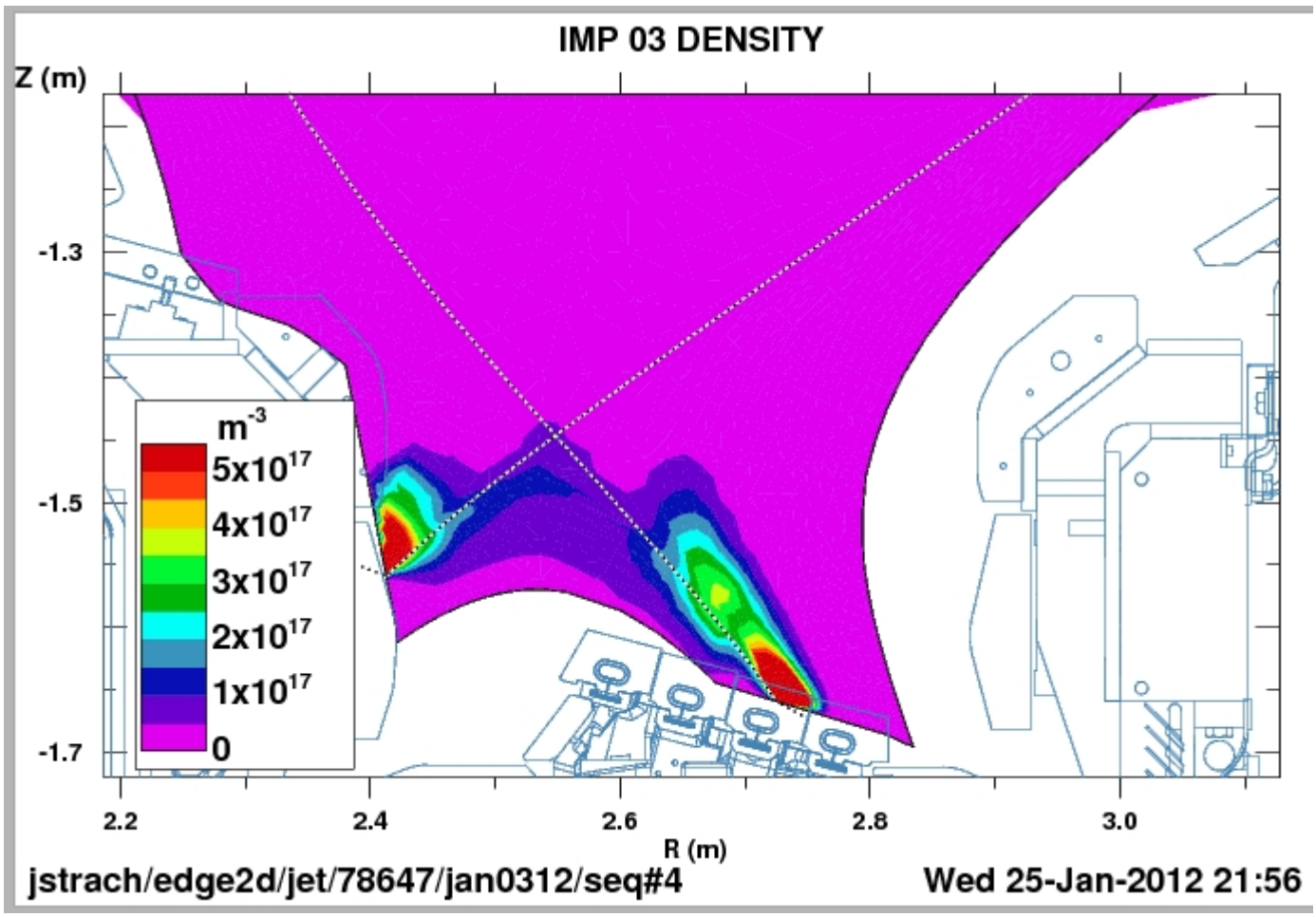
During an ELM: Impurity densities, divertor view.



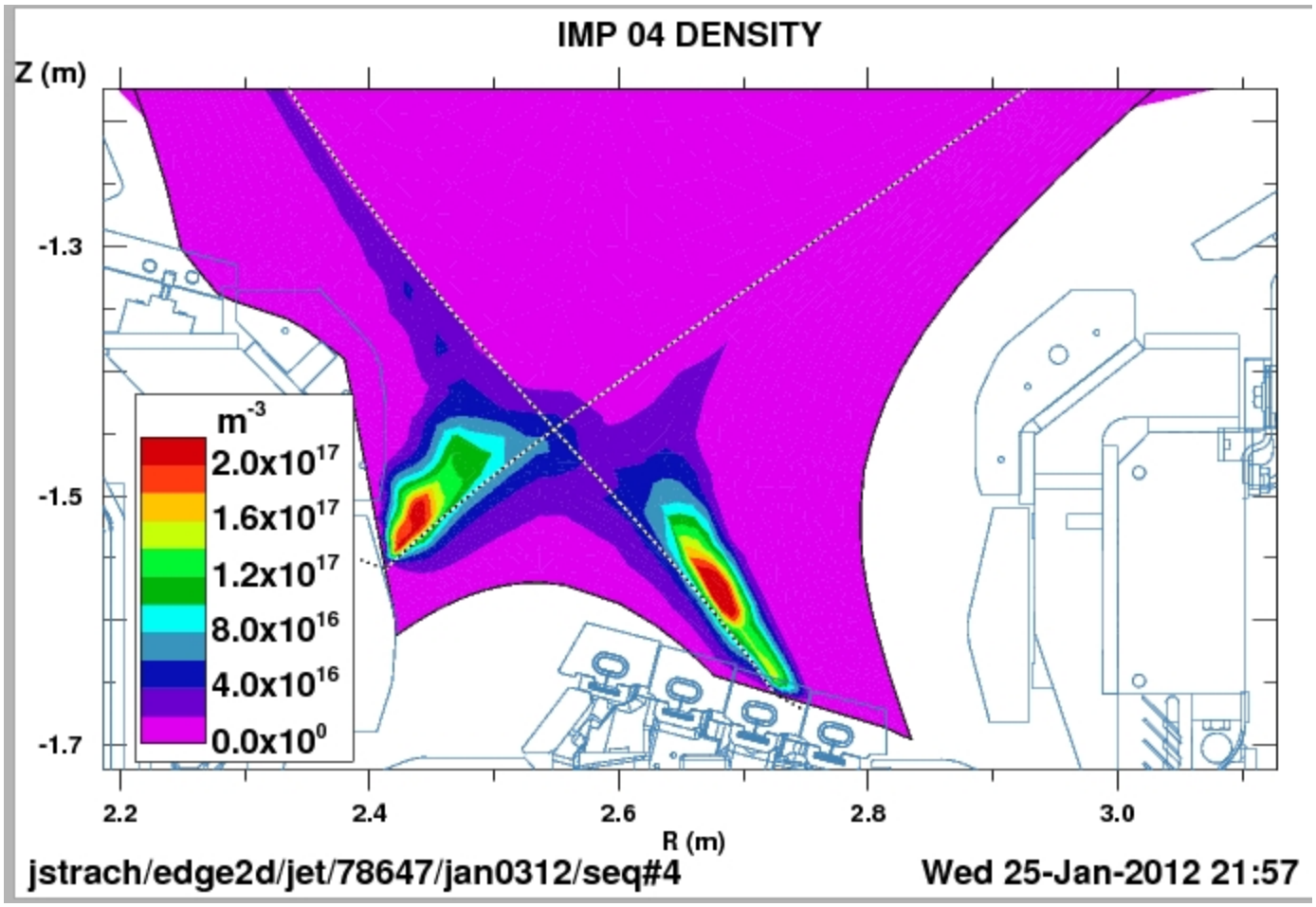
W^+ during an ELM



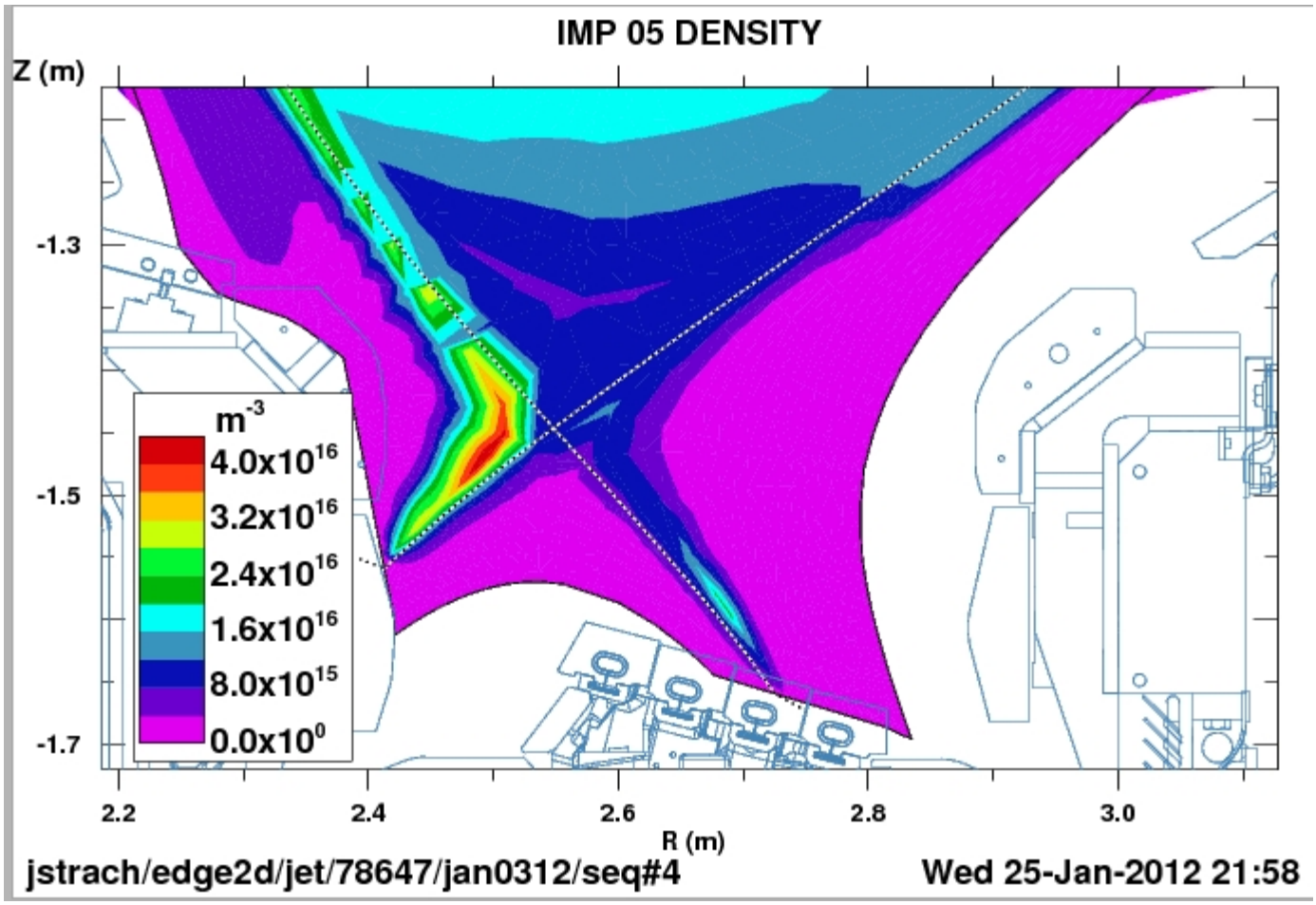
$W^{2+ \rightarrow 6+}$ during an ELM



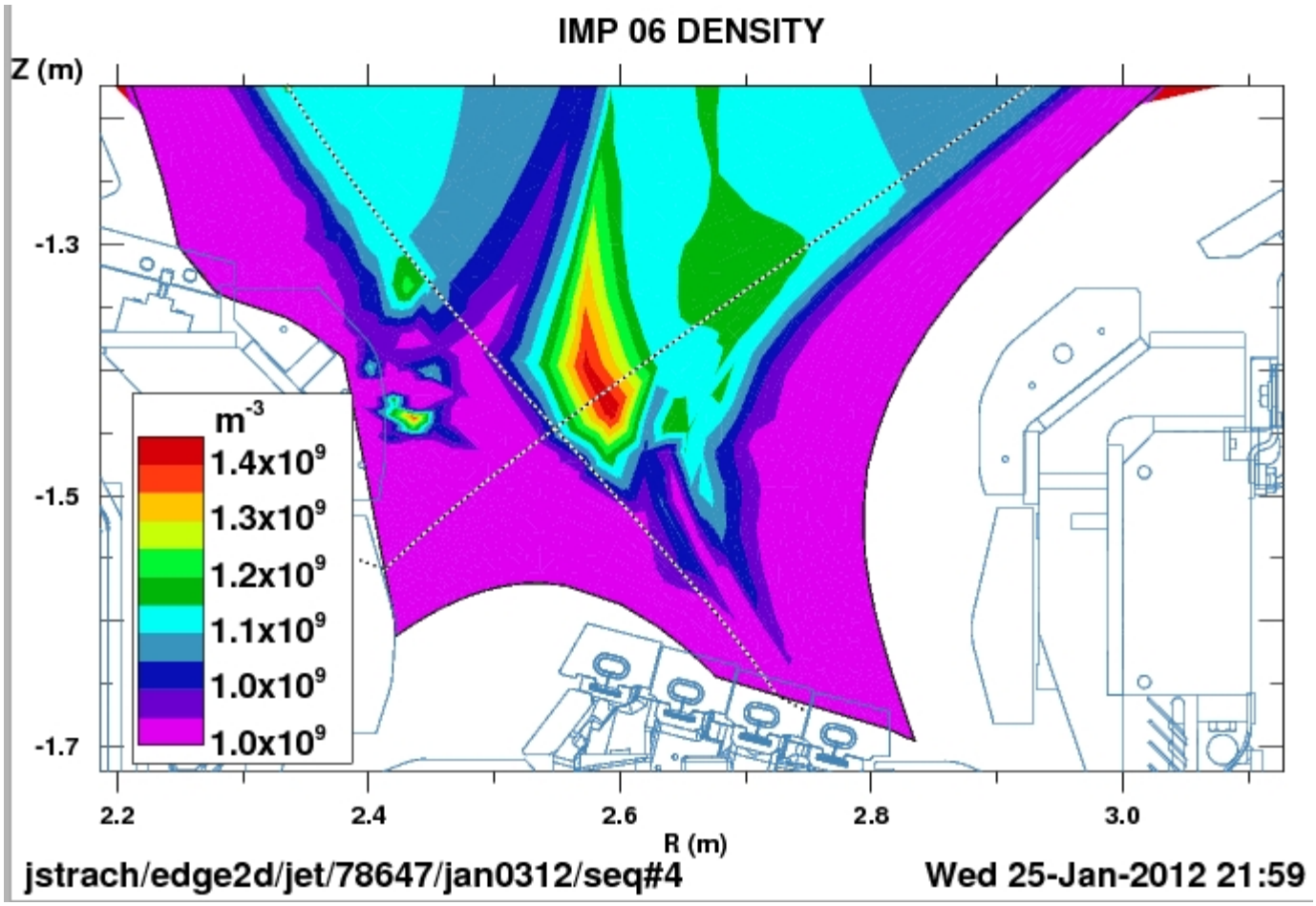
$W^{7+ \rightarrow 12+}$ during an ELM



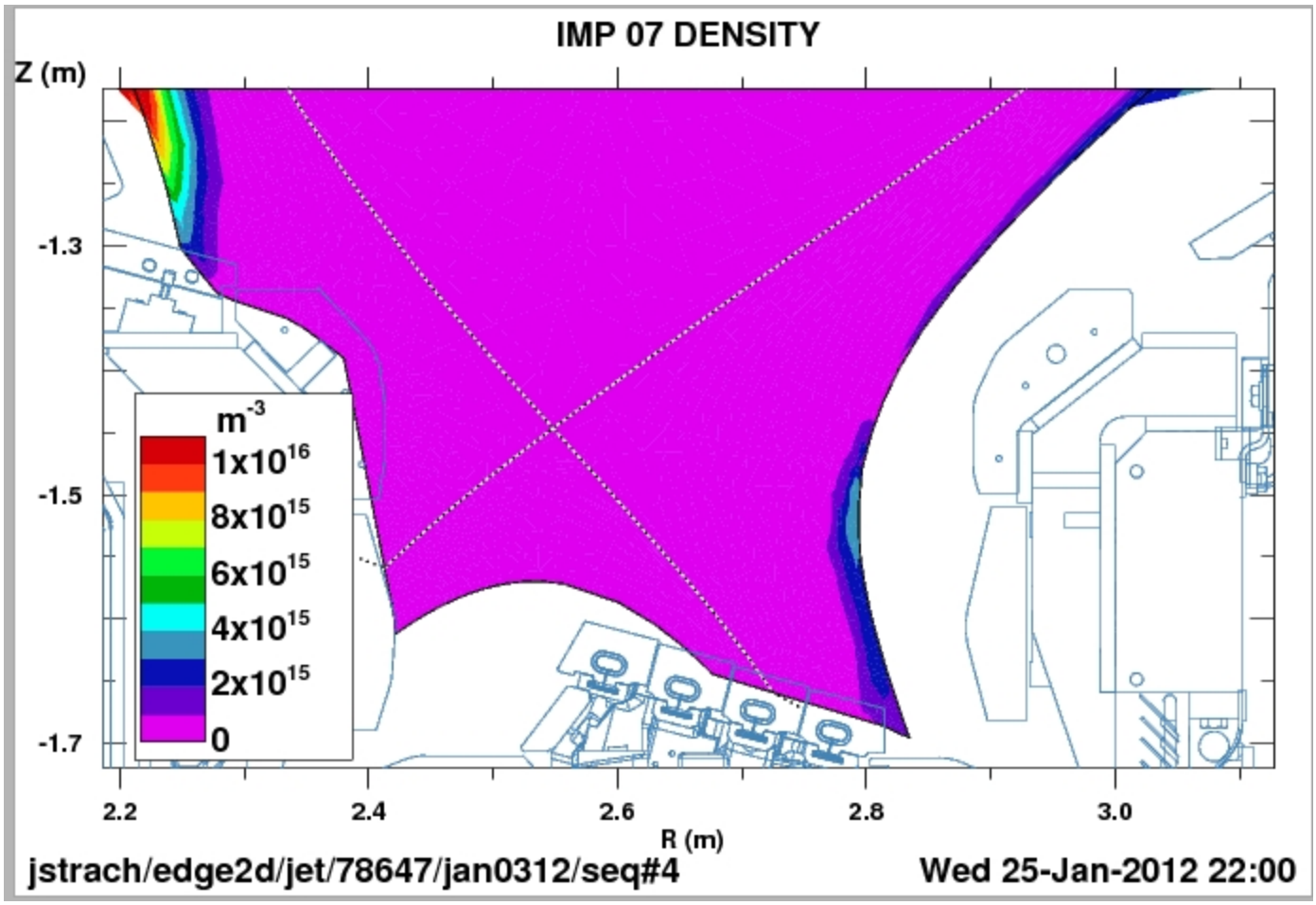
W bundle $^{13+ \rightarrow 22+}$ during an ELM



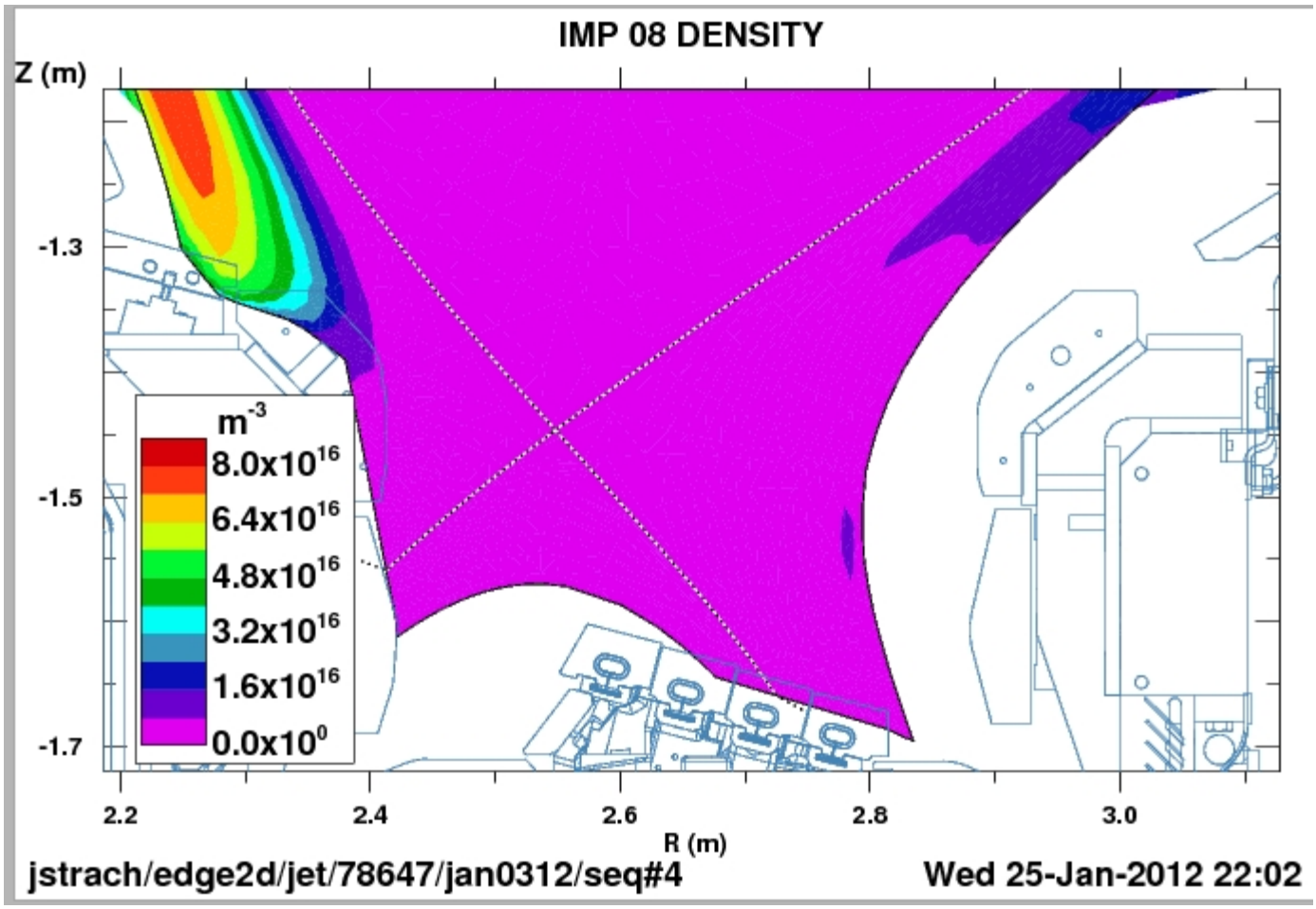
$W^{23+ \rightarrow 73+}$ during an ELM



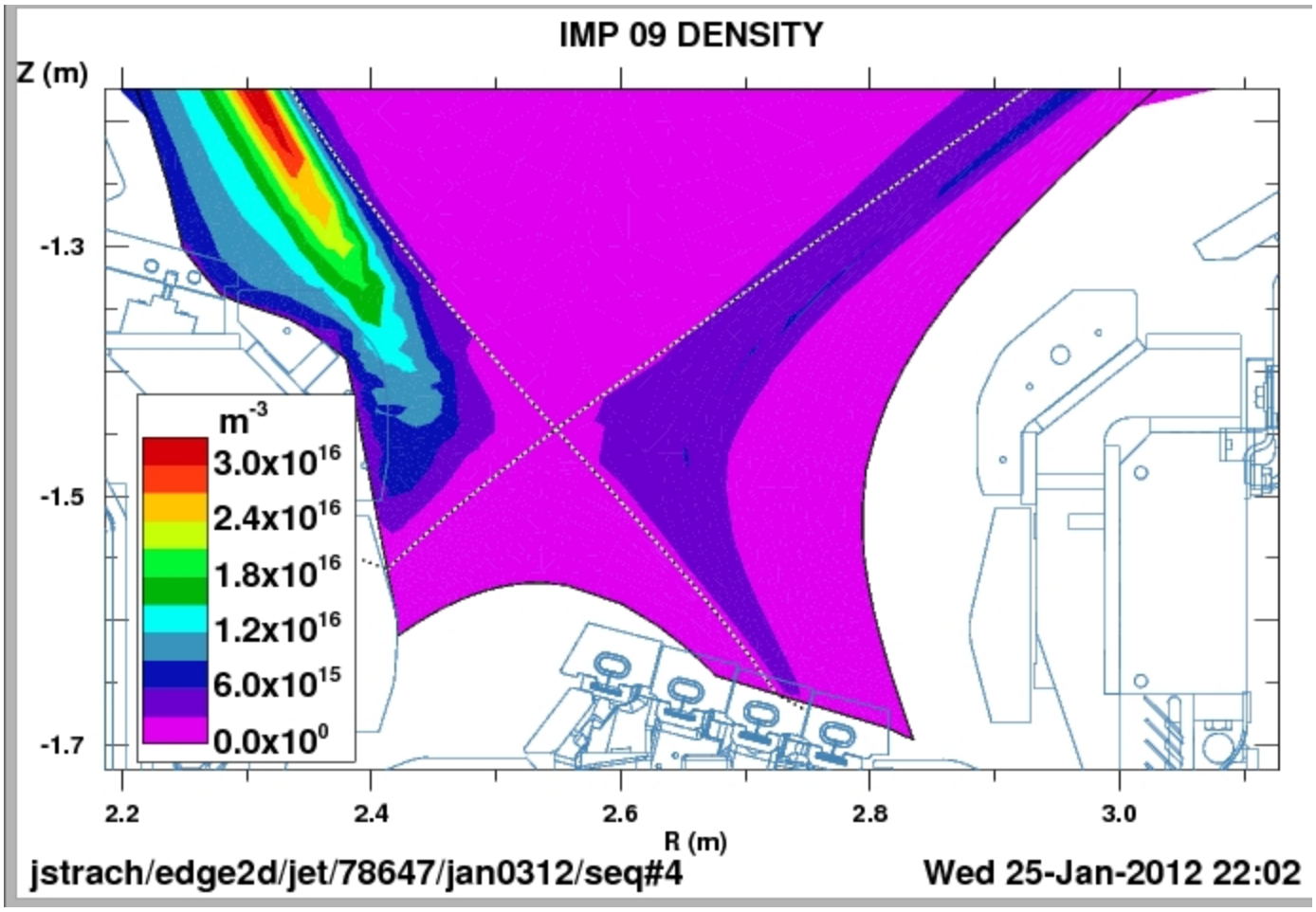
W^{74+} during an ELM



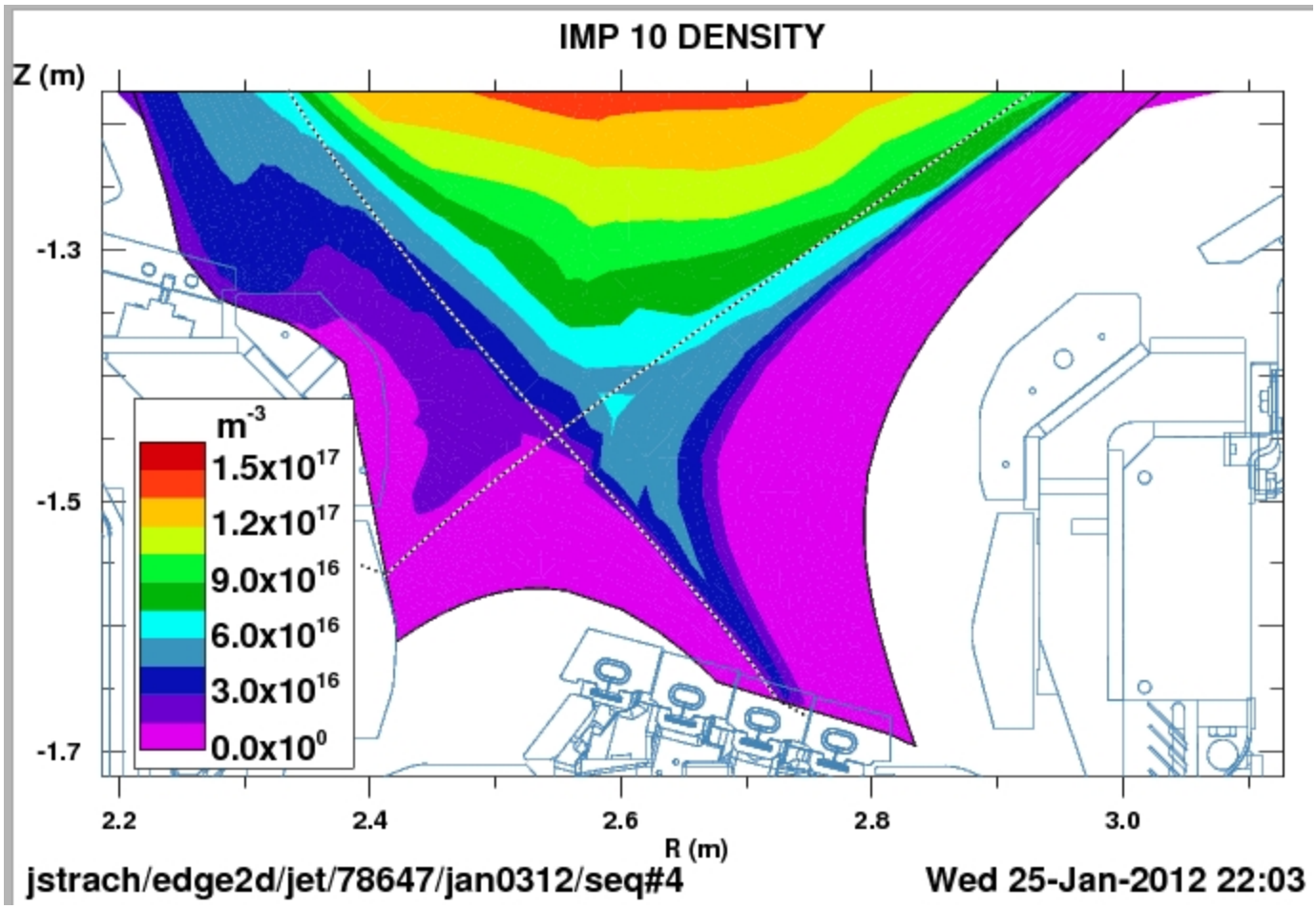
Be 1^{+} during an ELM



Be 2^{+} during an ELM

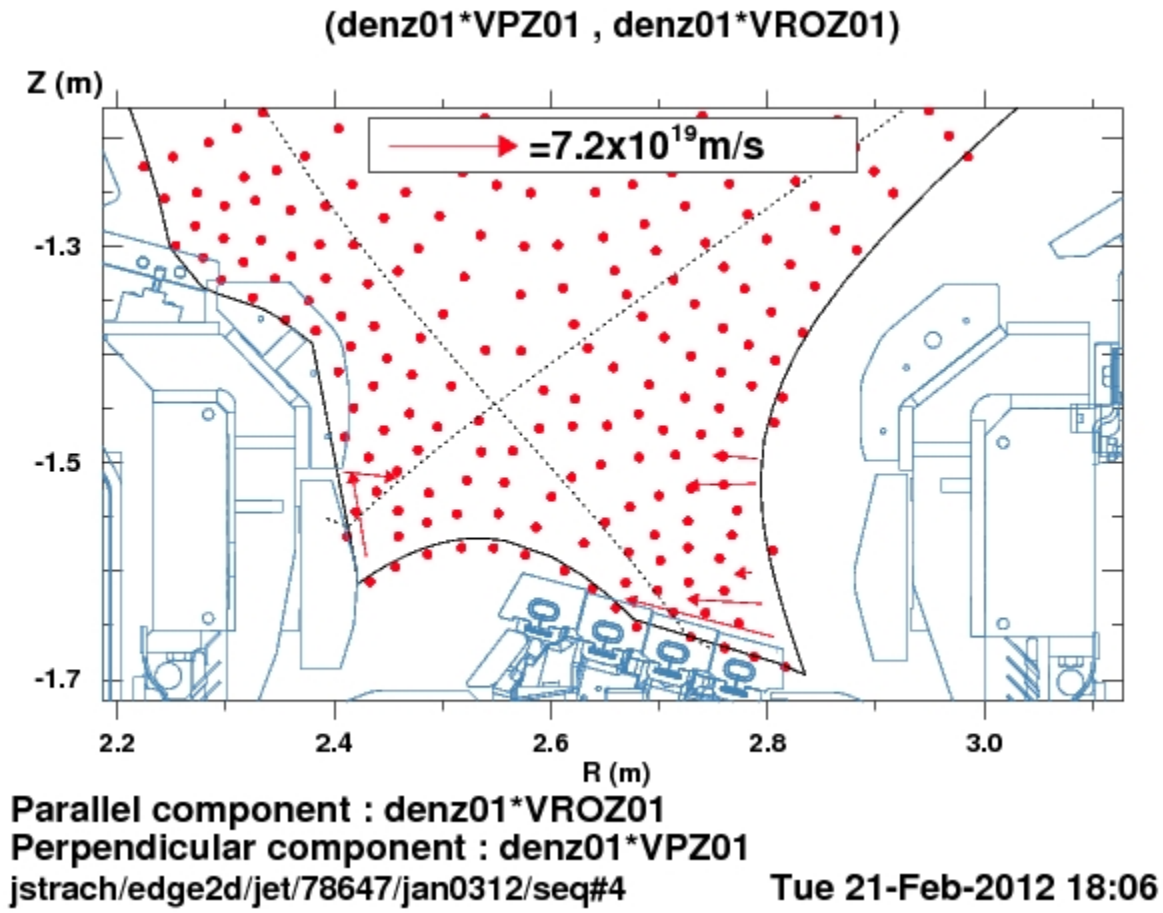


Be 3^{+} during an ELM

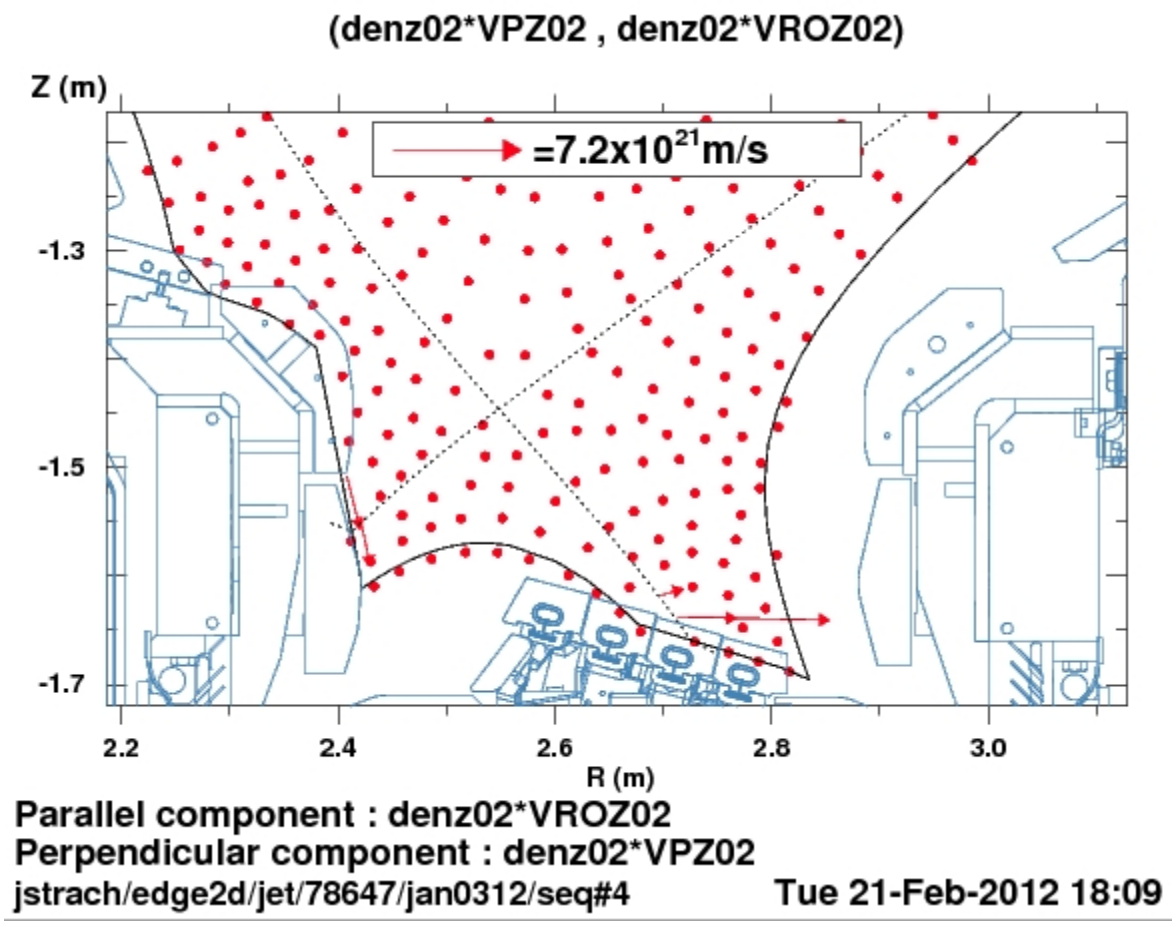


Be 4^{+} during an ELM

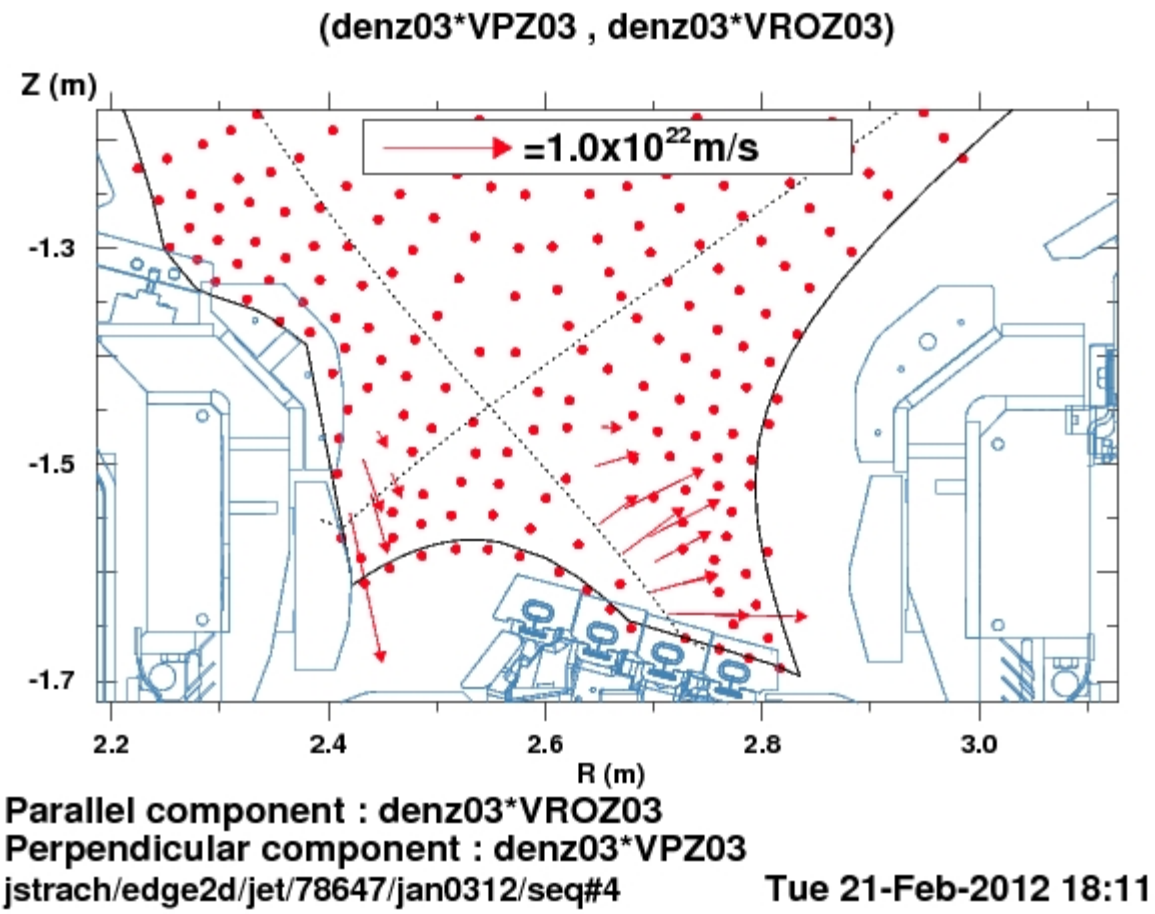
During an ELM: Impurity flux vectors, divertor view.



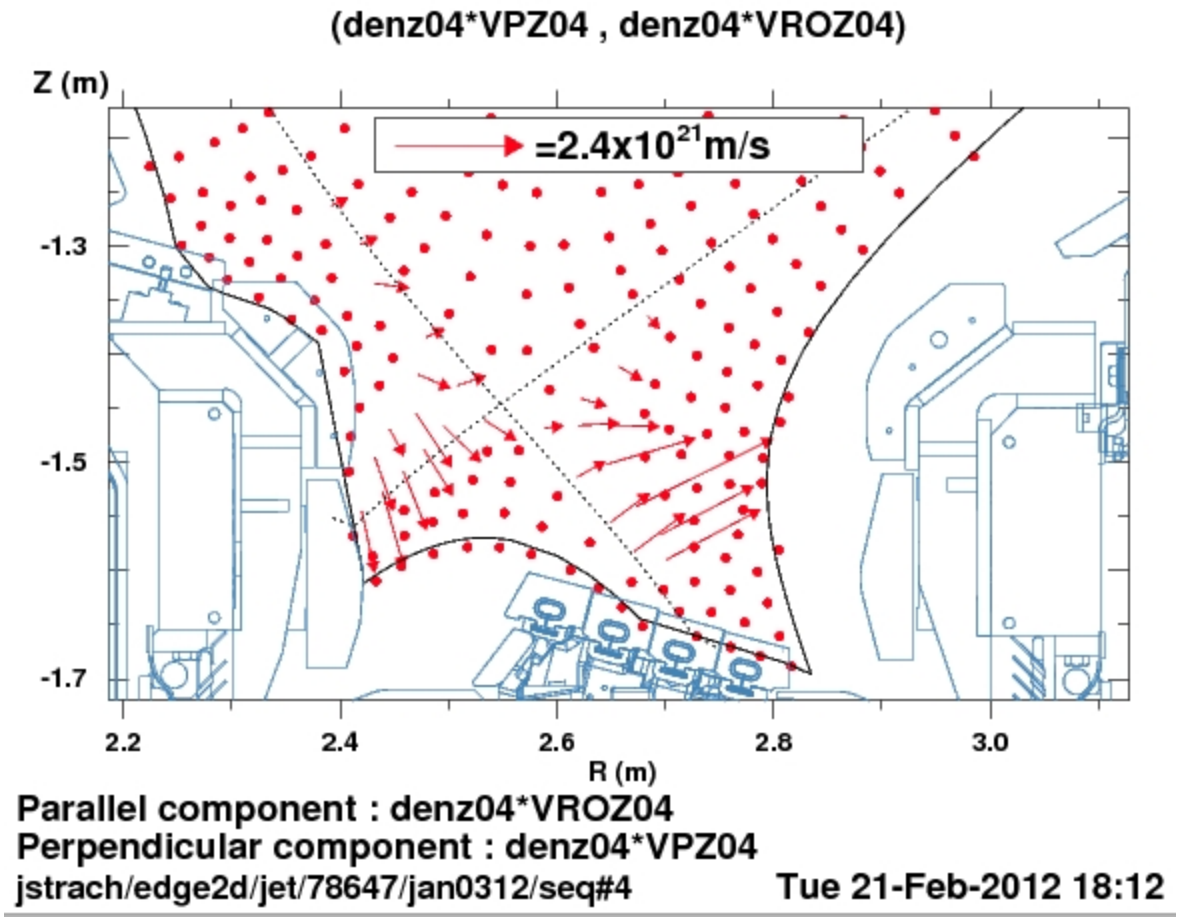
W^+ flux during an ELM



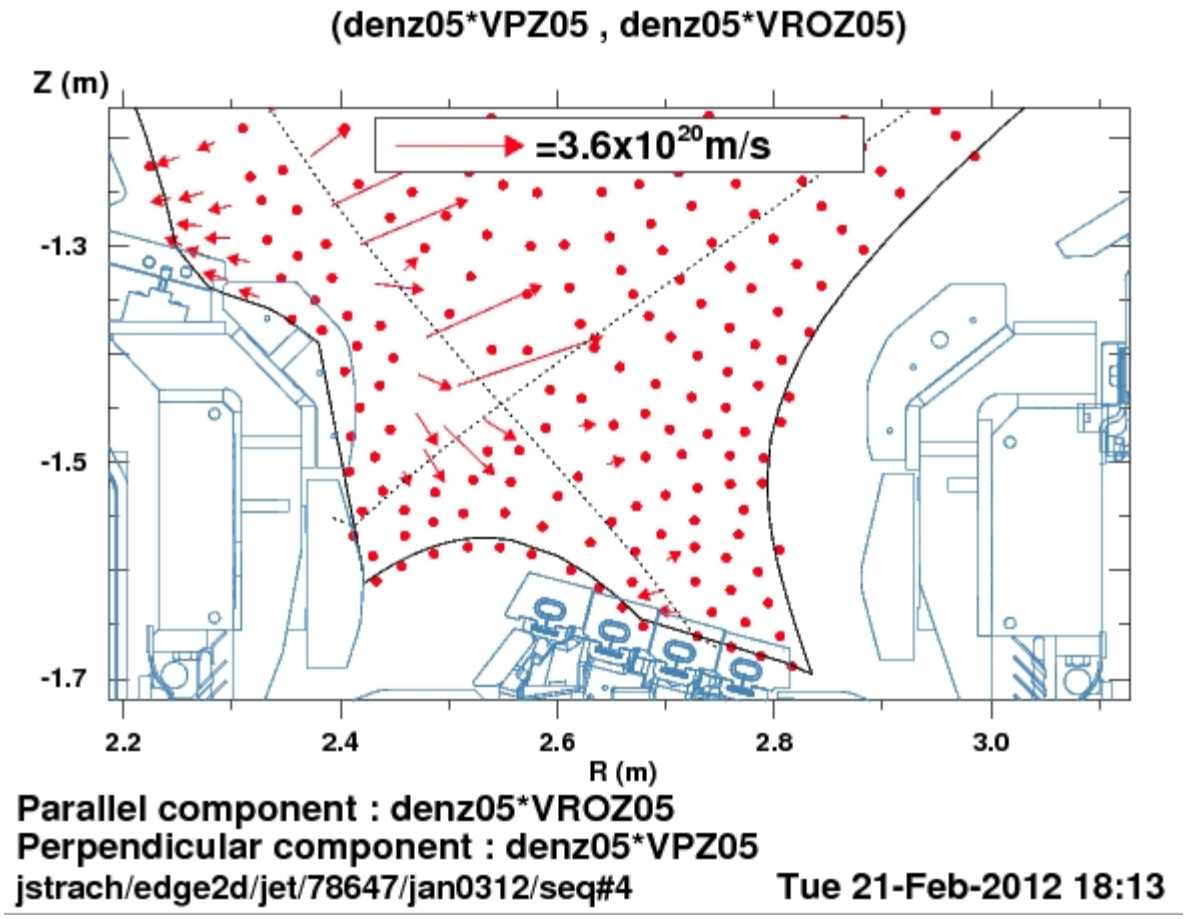
$W^{2+ \rightarrow 6+}$ flux during an ELM



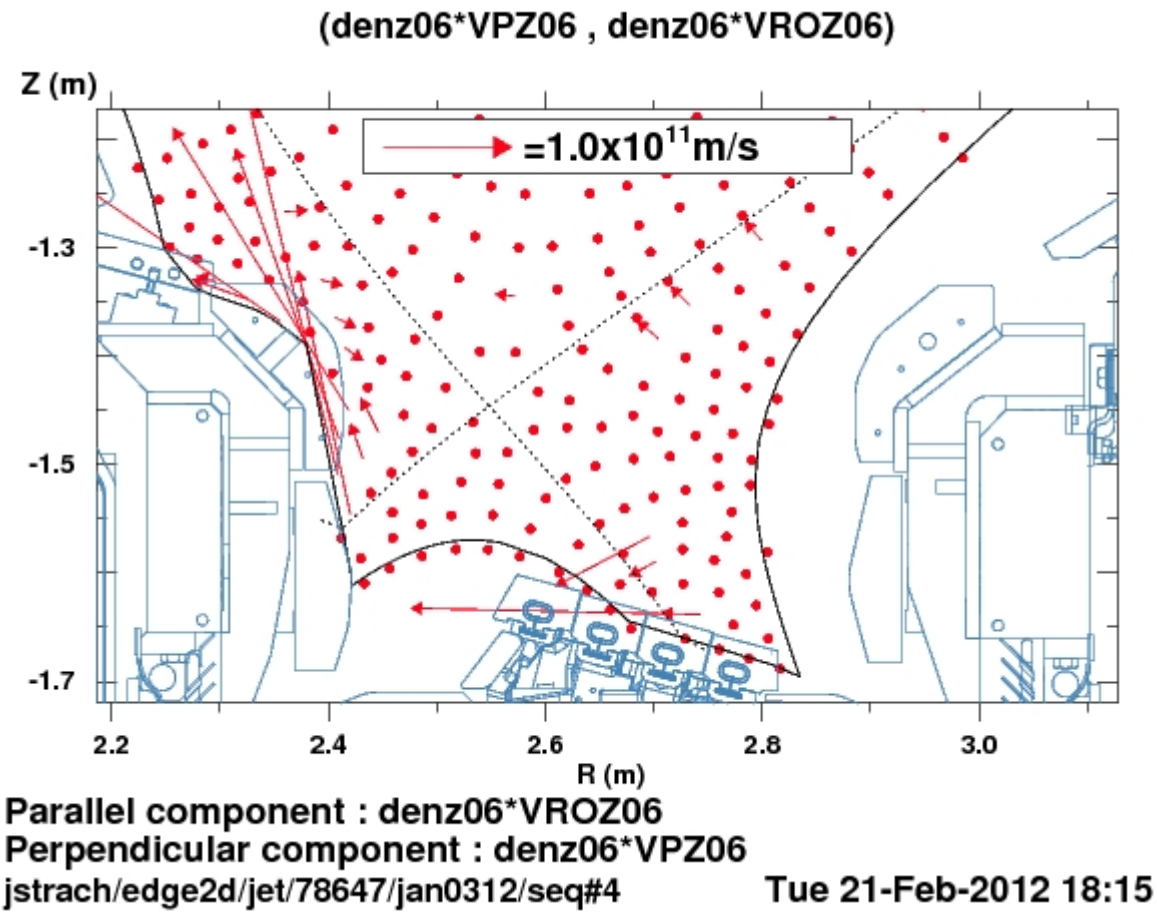
$W^{7+ \rightarrow 12+}$ flux during an ELM



W bundle $^{13+ \rightarrow 22+}$ flux during an ELM

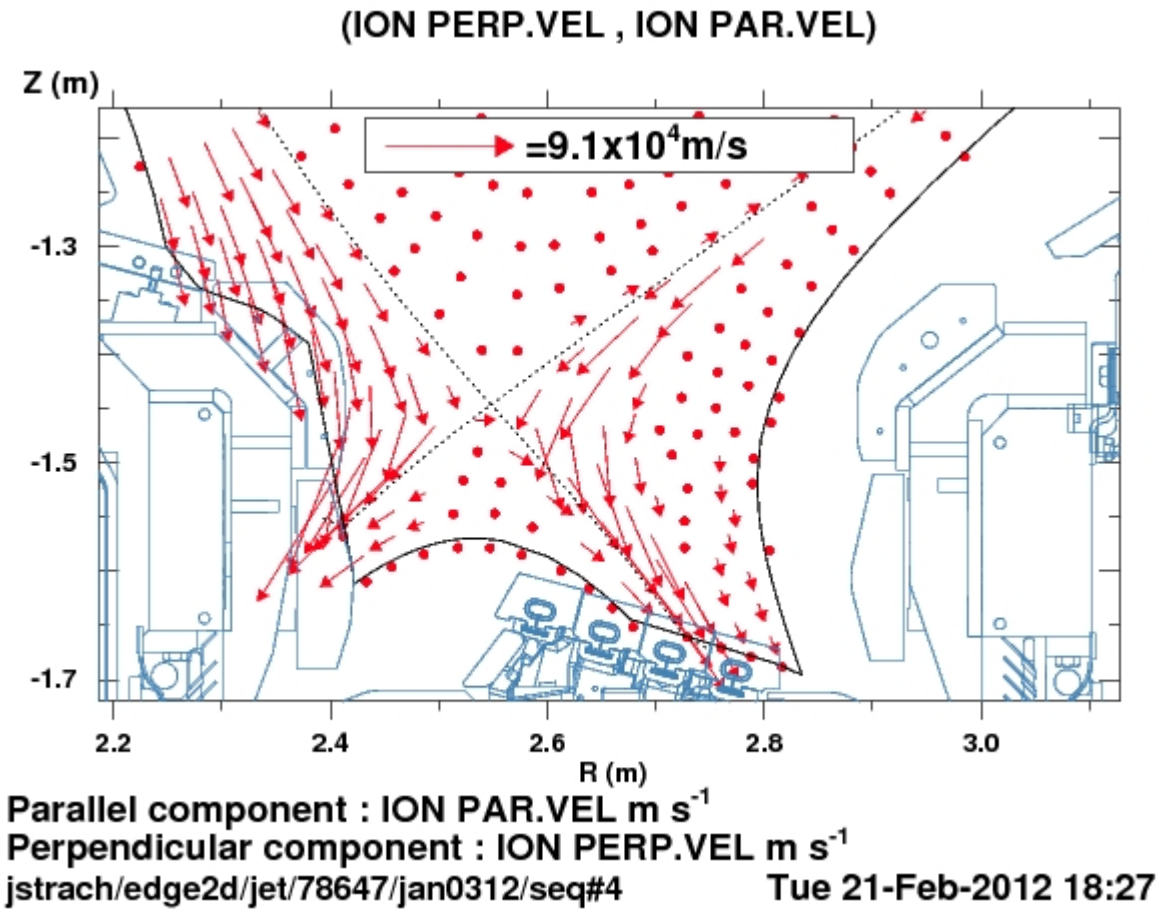


$W^{23+ \rightarrow 73+}$ flux during an ELM

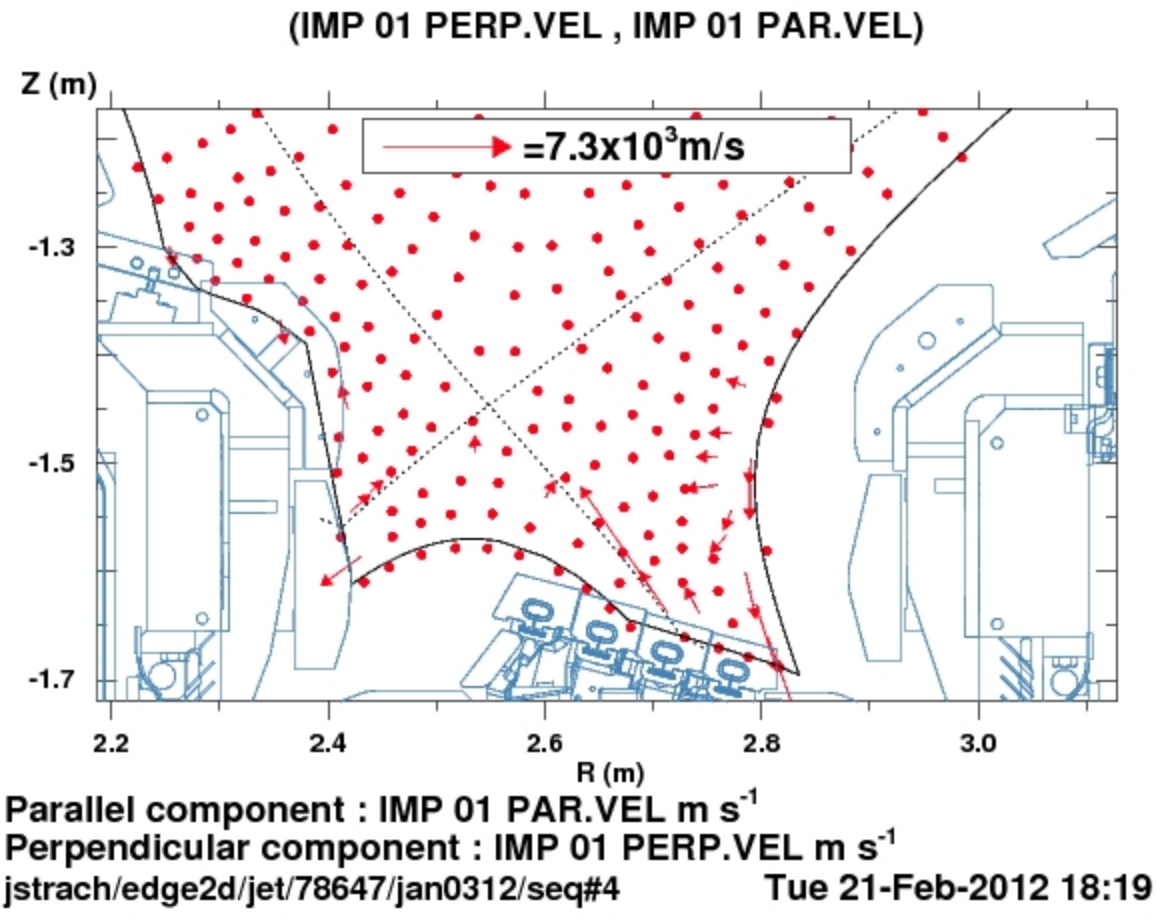


W^{74+} flux during an ELM

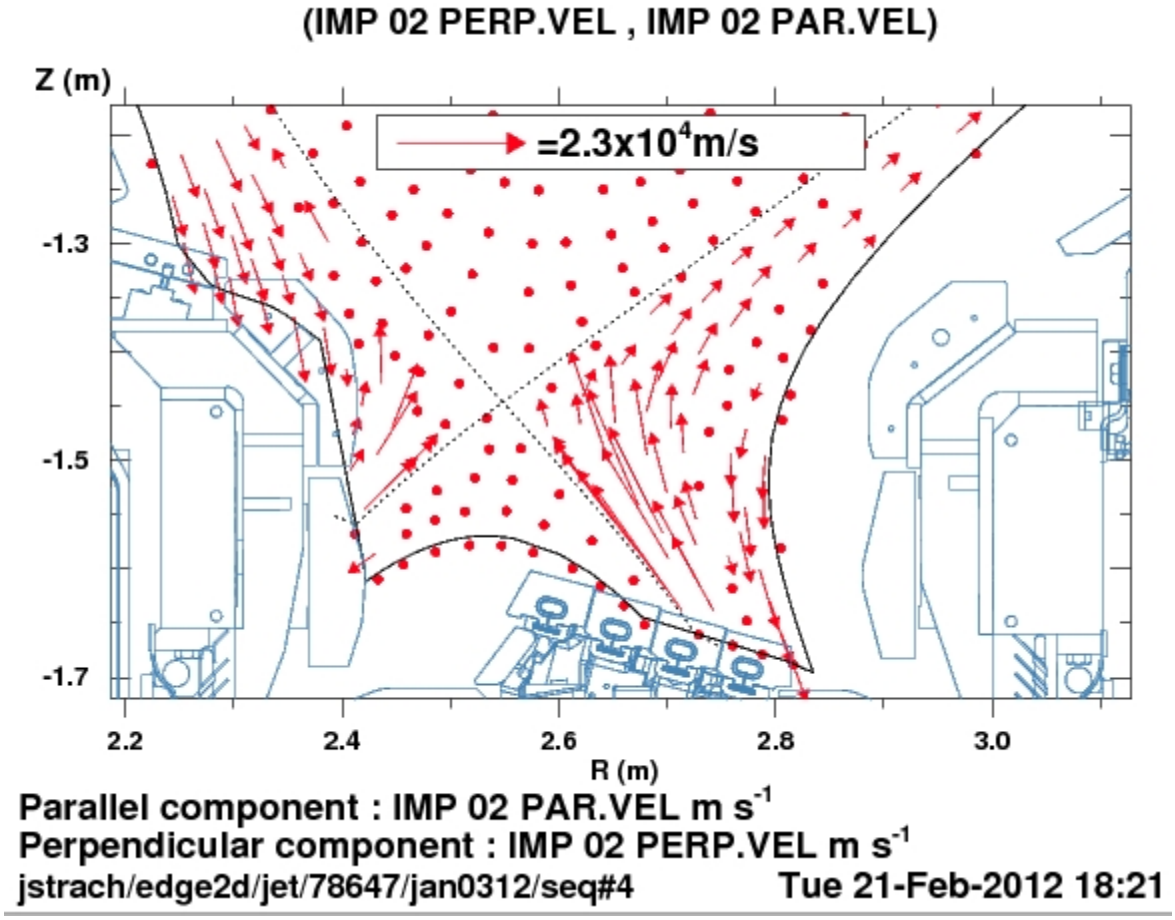
During an ELM: Particle velocity vectors, divertor view.



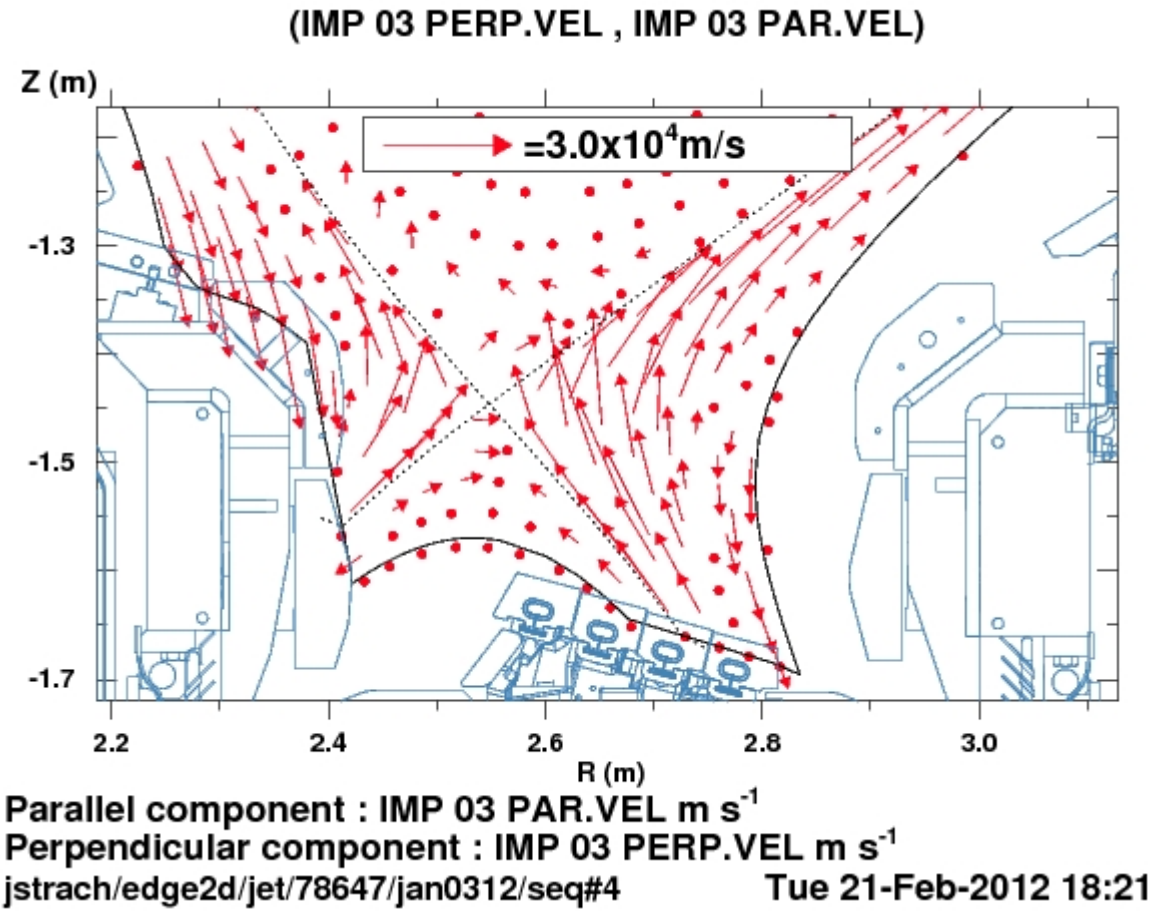
D during an ELM



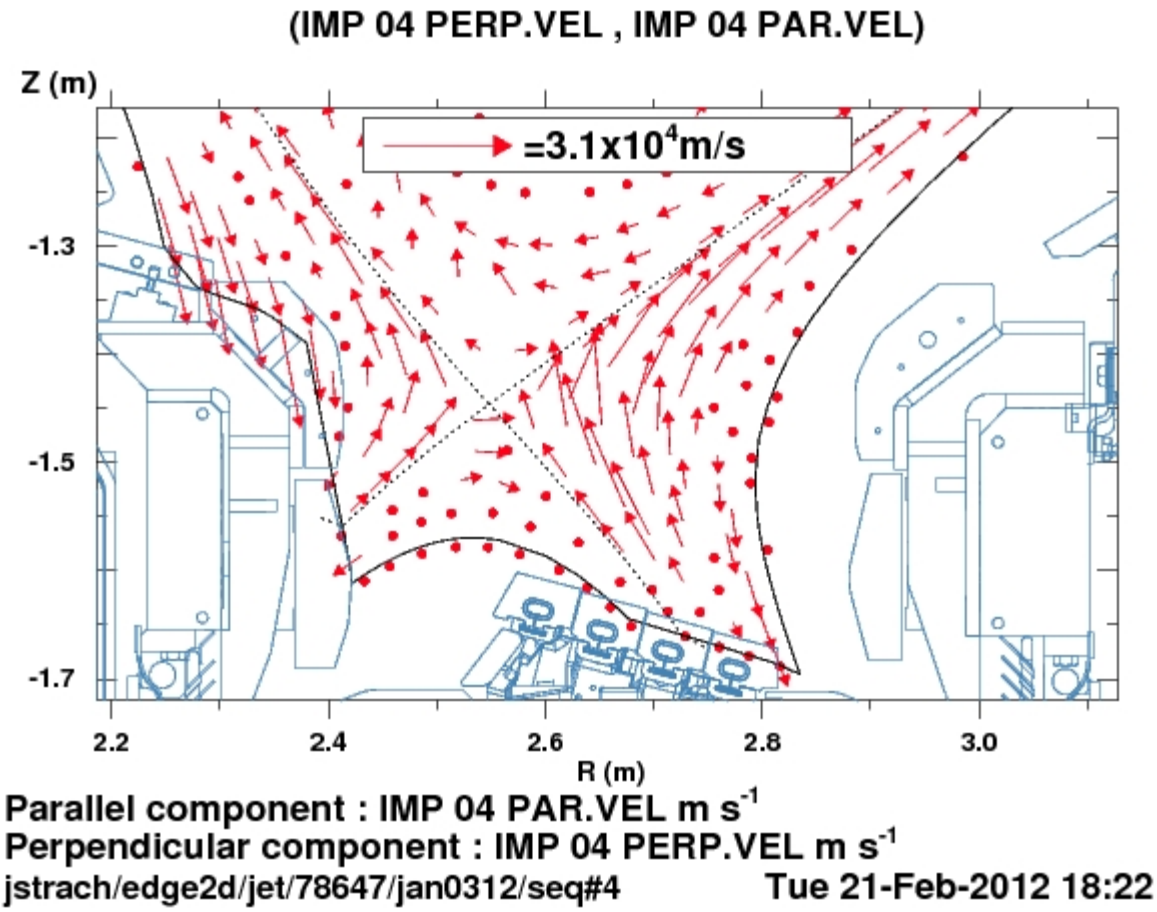
W^+ during an ELM



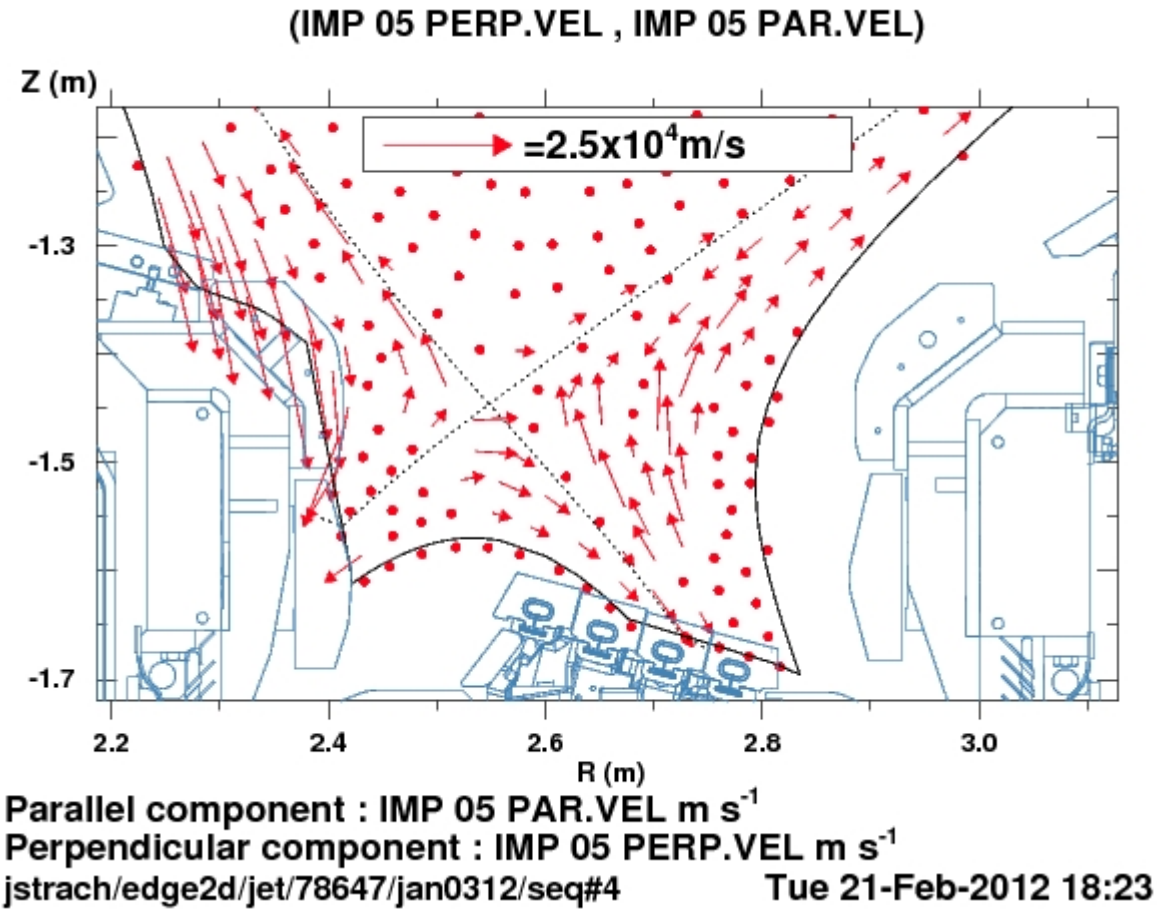
$W^{2+ \rightarrow 6+}$ during an ELM



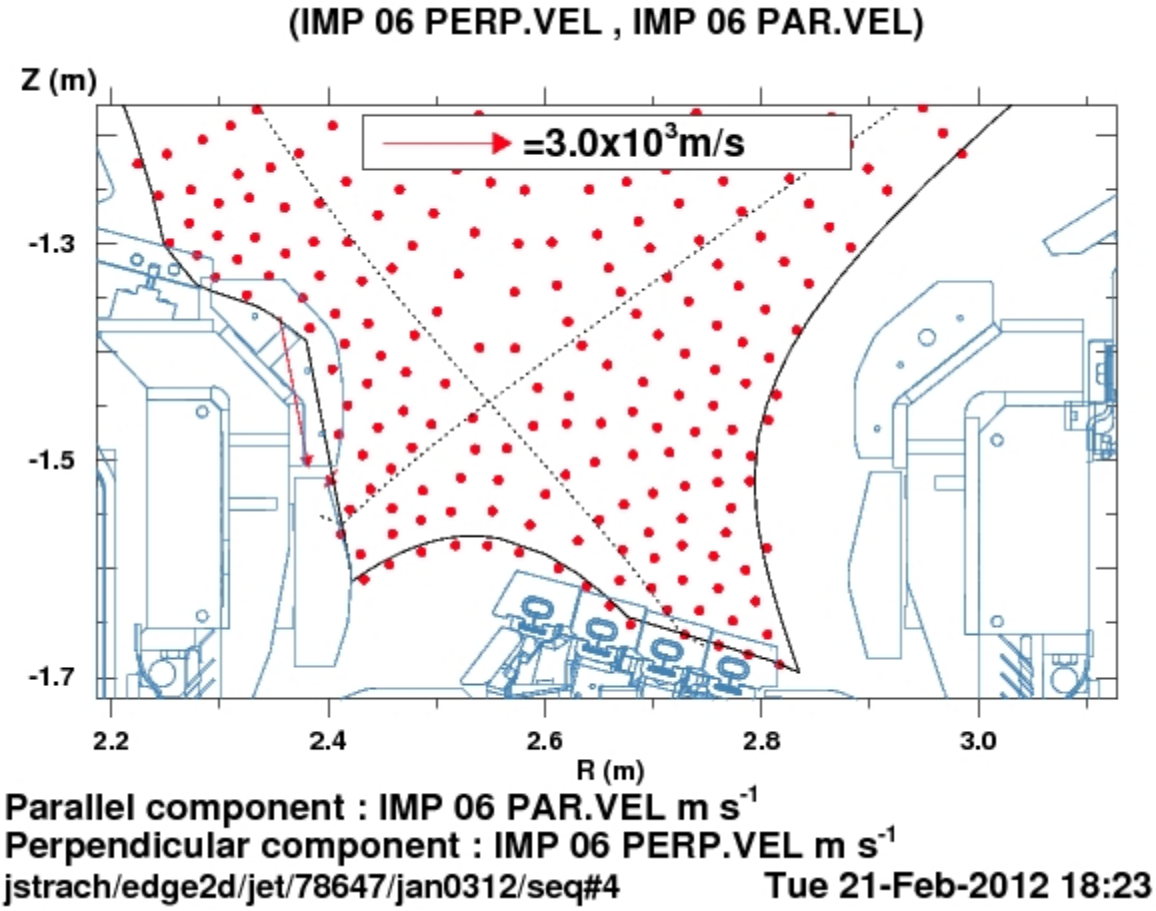
$W^{7+ \rightarrow 12+}$ during an ELM



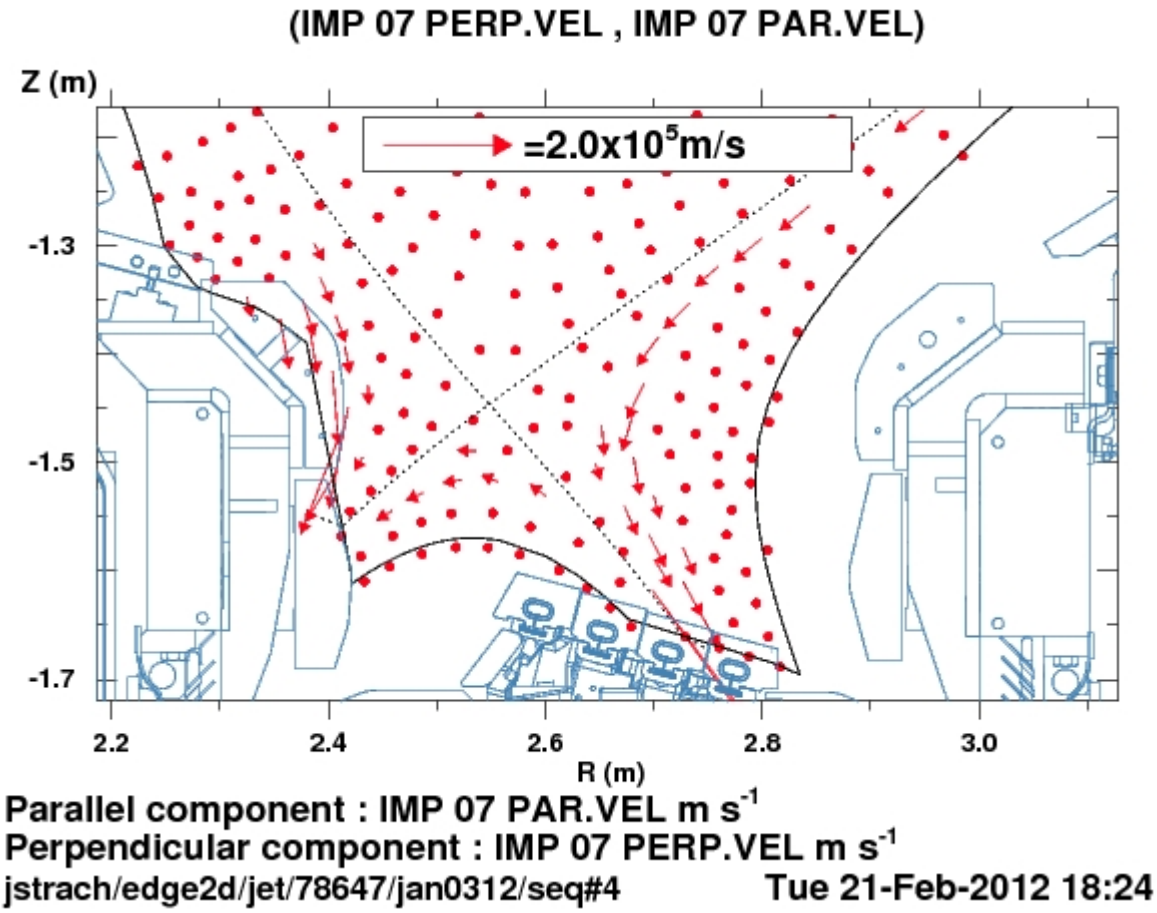
W bundle $^{13+ \rightarrow 22+}$ during an ELM



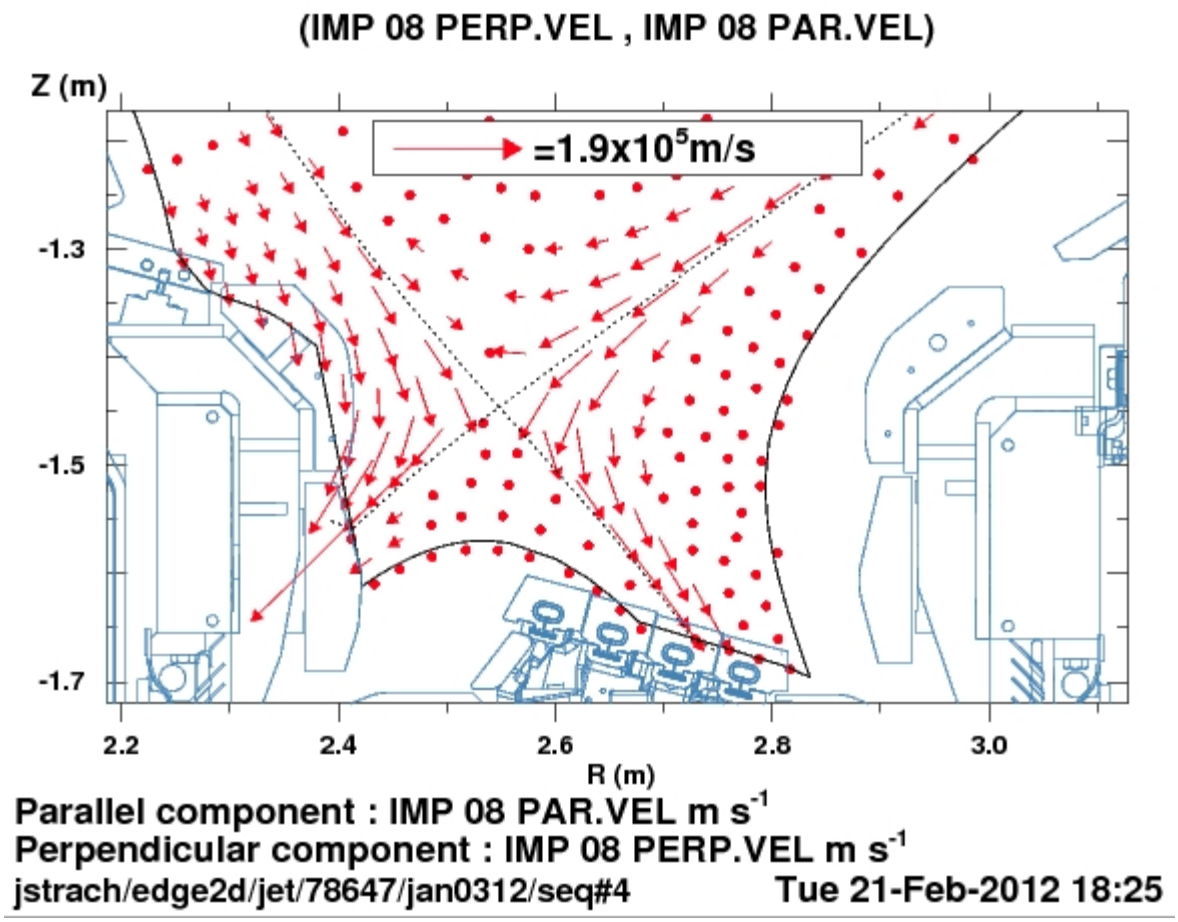
$W^{23+ \rightarrow 73+}$ during an ELM



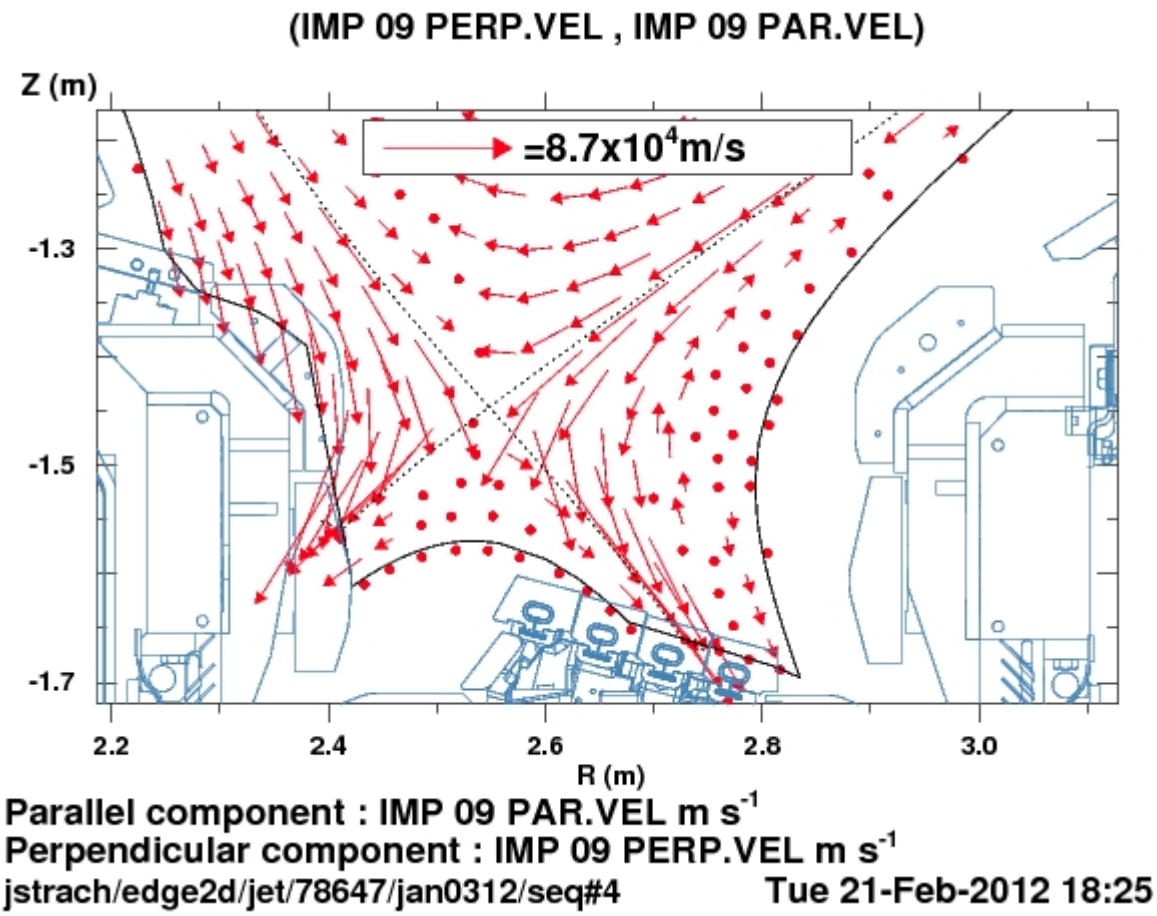
W^{74+} during an ELM



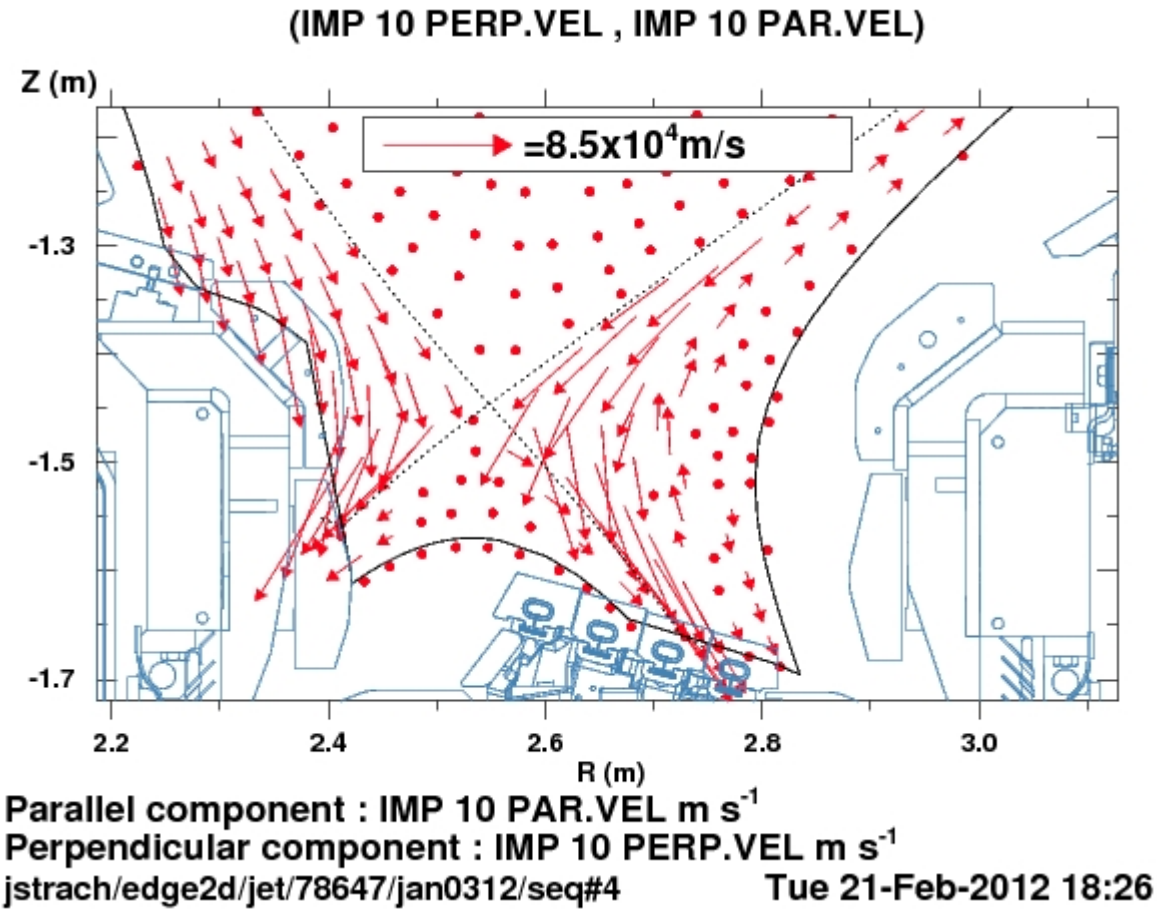
Be 1^{+} during an ELM



Be 2^{+} during an ELM

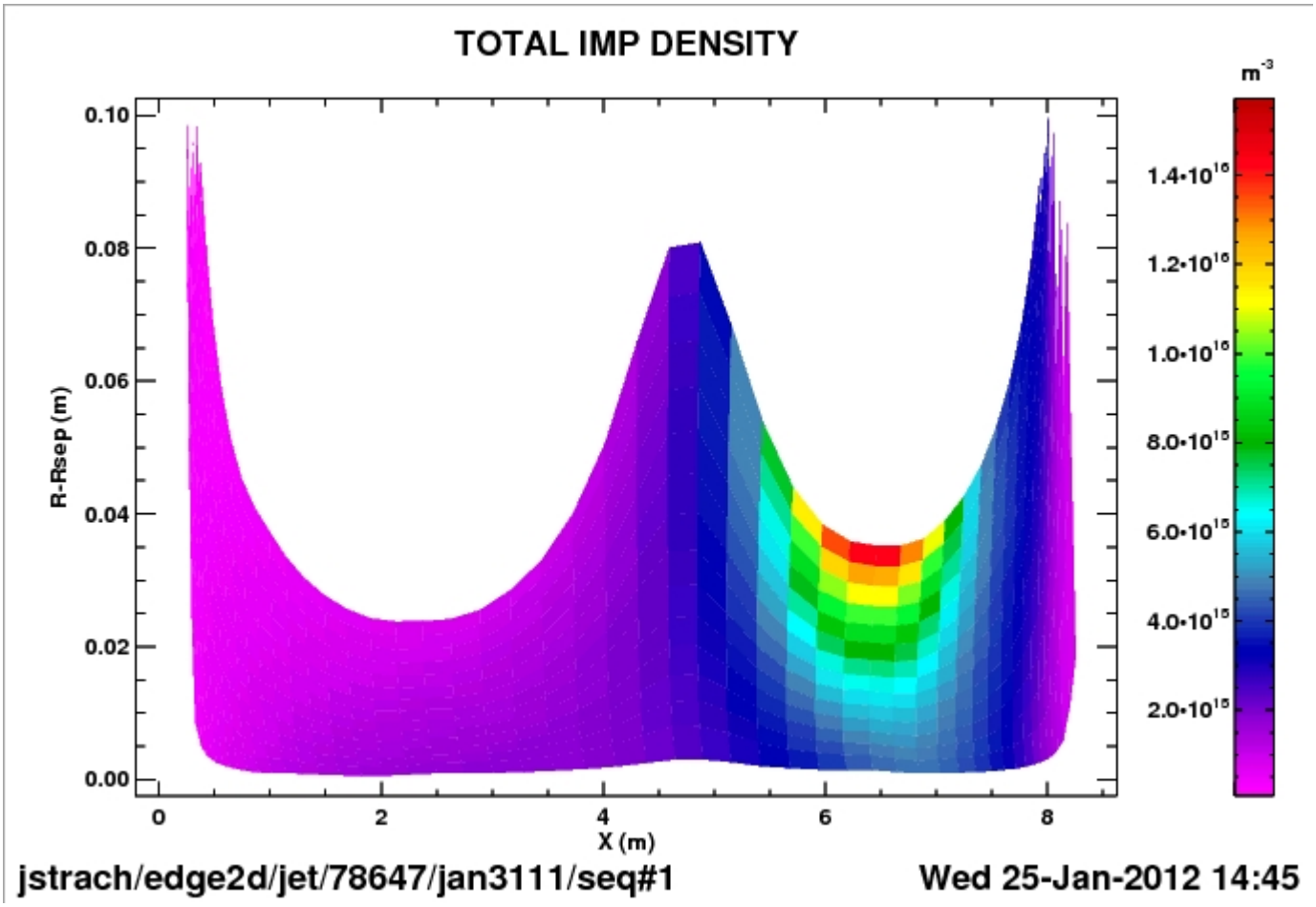


Be 3^{+} during an ELM

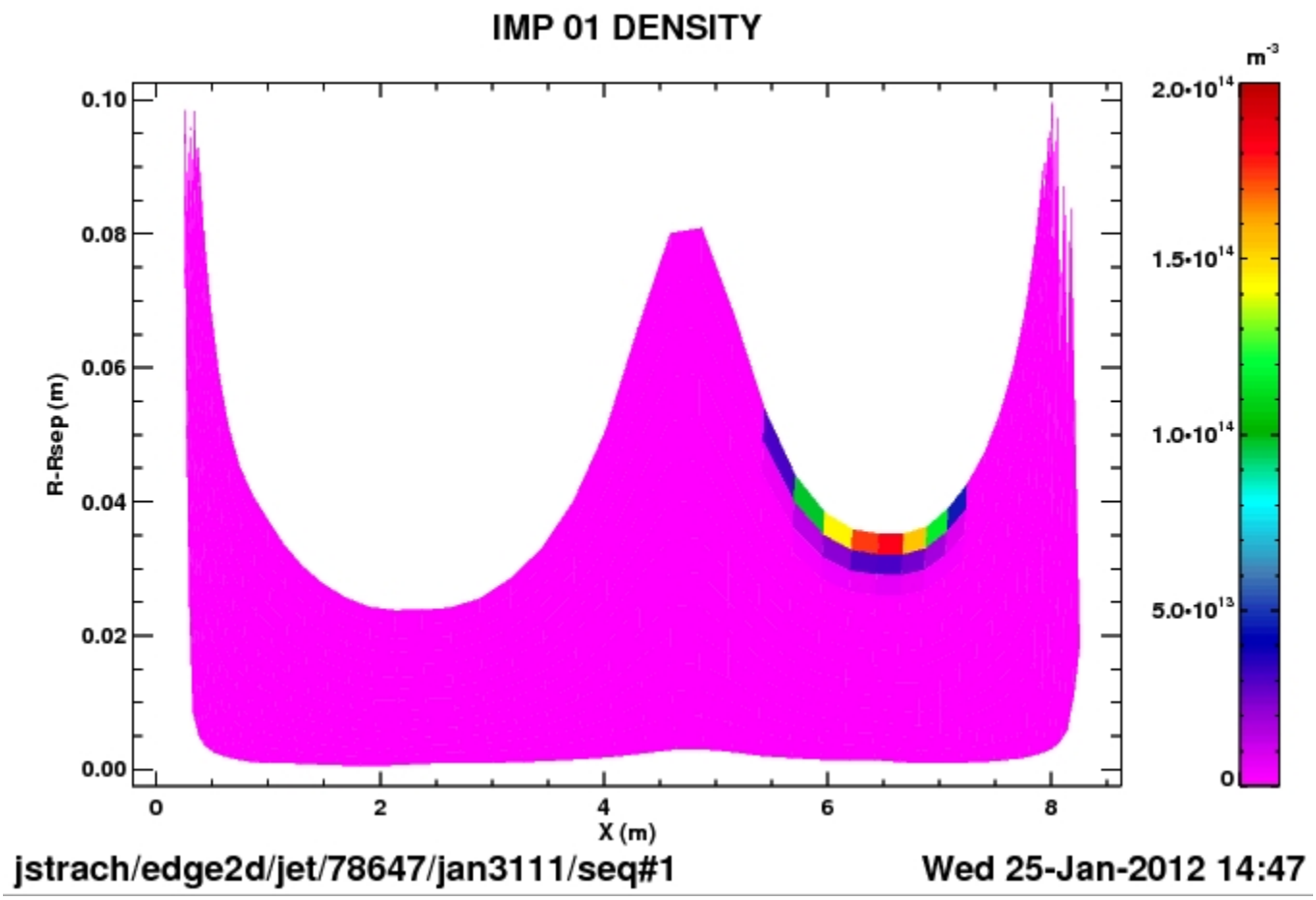


Be 4^+ during an ELM

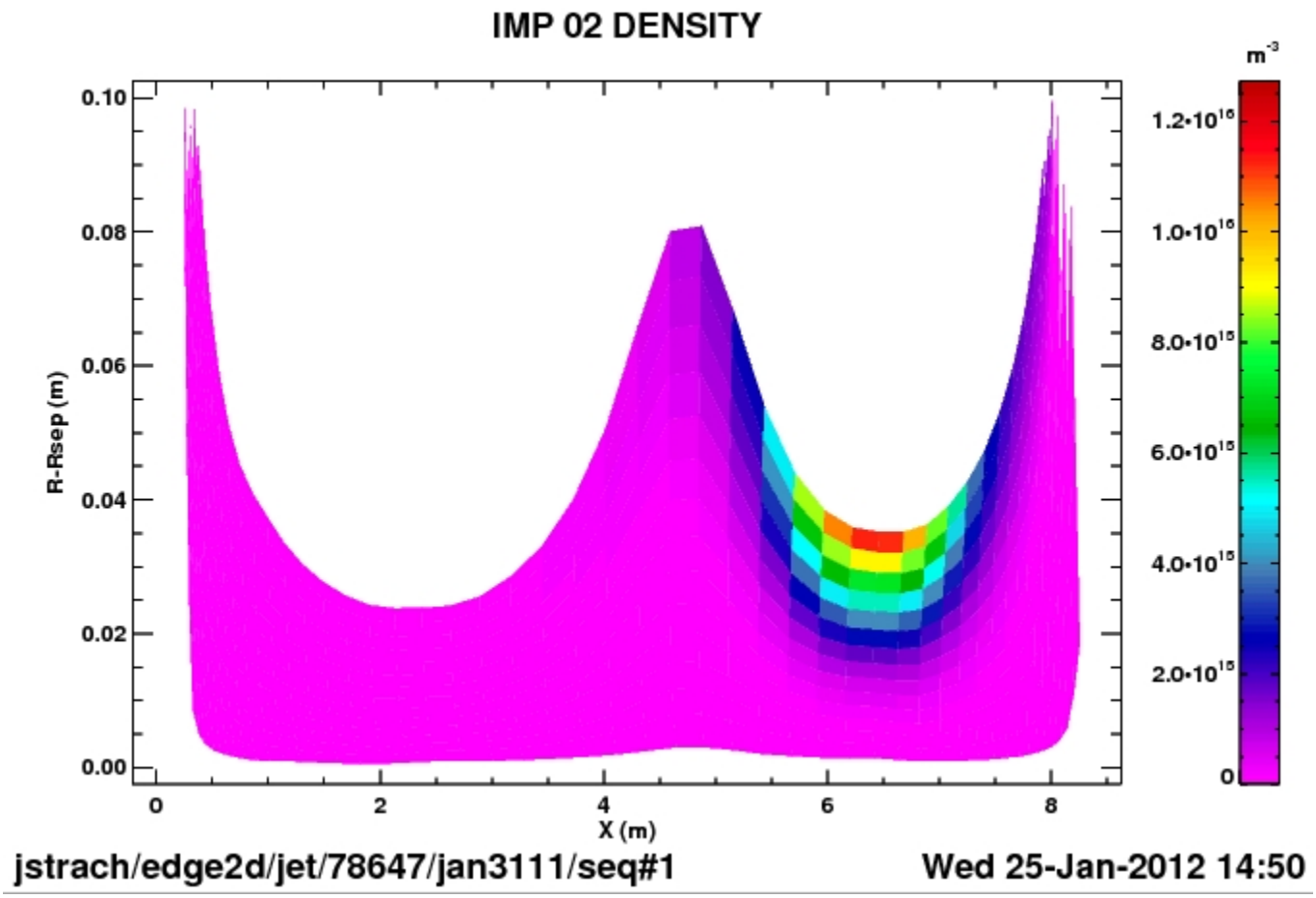
Puffing Case: Impurity densities, main chamber view.



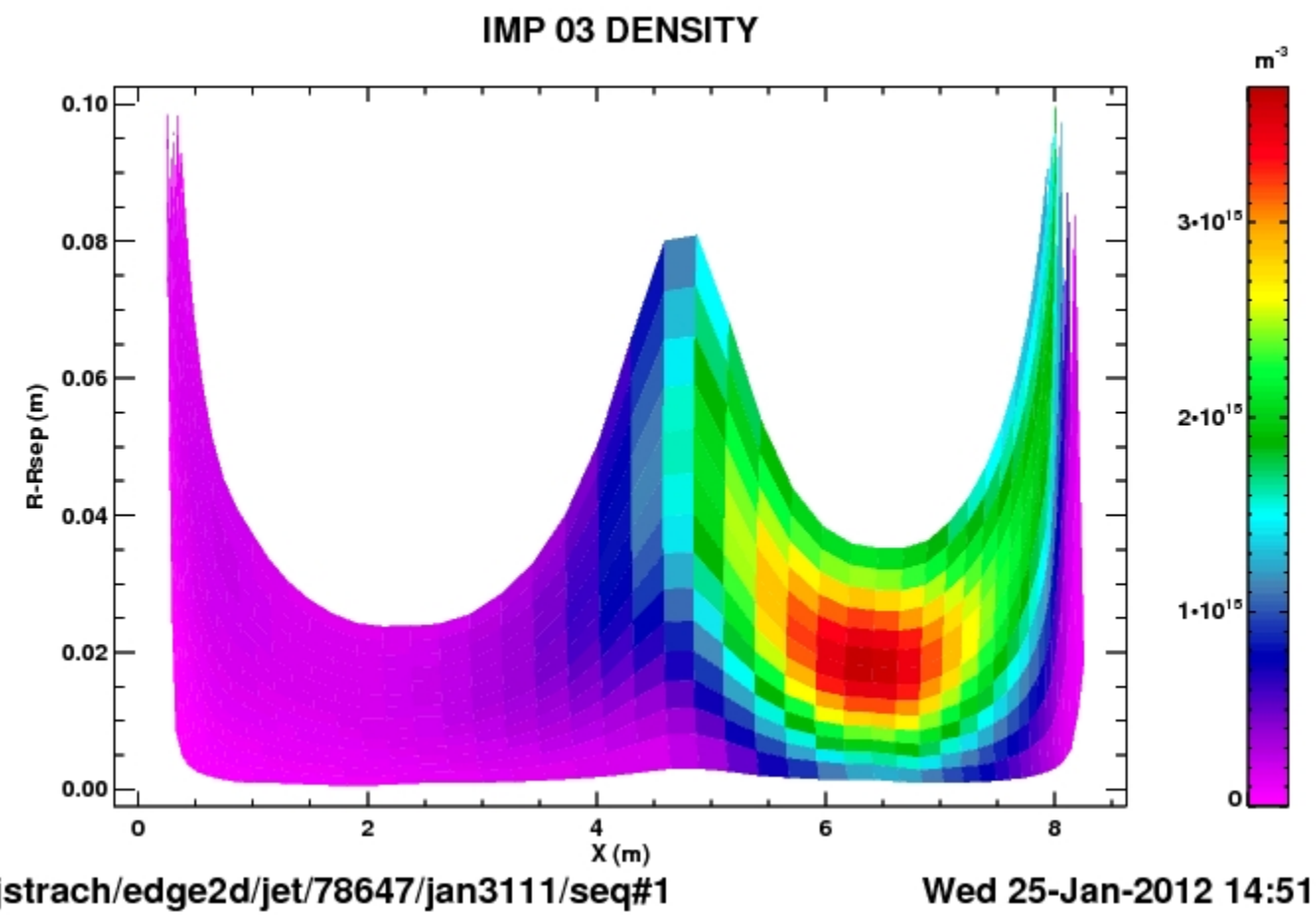
W Puffing from inner mid-plane on vessel. No Be in calculation.


IMP 01 DENSITY
m-3
2.0•10^14
1.5•10^14
1.0•10^14
5.0•10^13
0
R-Rsep (m)
0.10
0.08
0.06
0.04
0.02
0.00
0
2
4
6
8
X (m)
jstrach/edge2d/jet/78647/jan3111/seq#1
Wed 25-Jan-2012 14:47

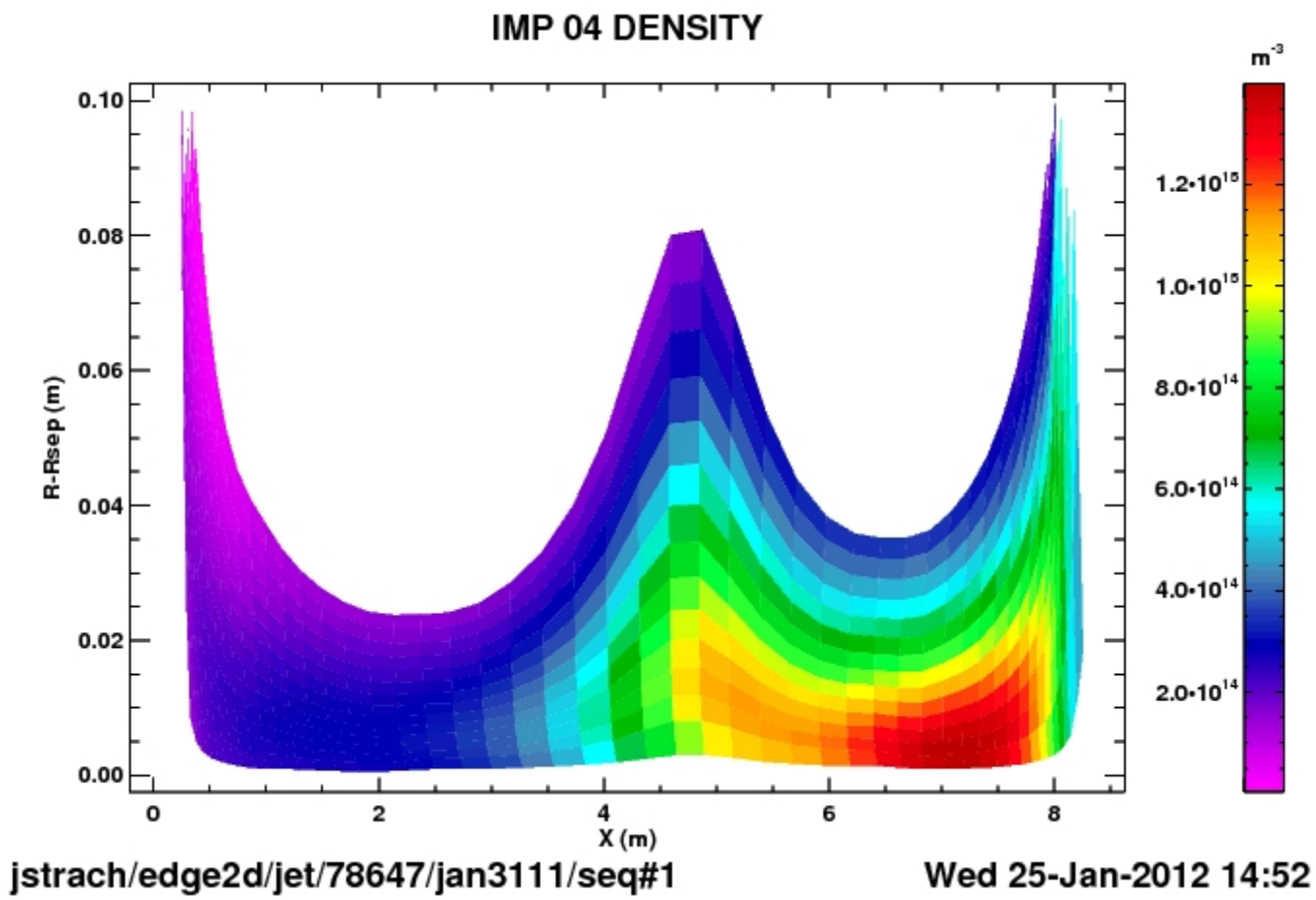
W^+



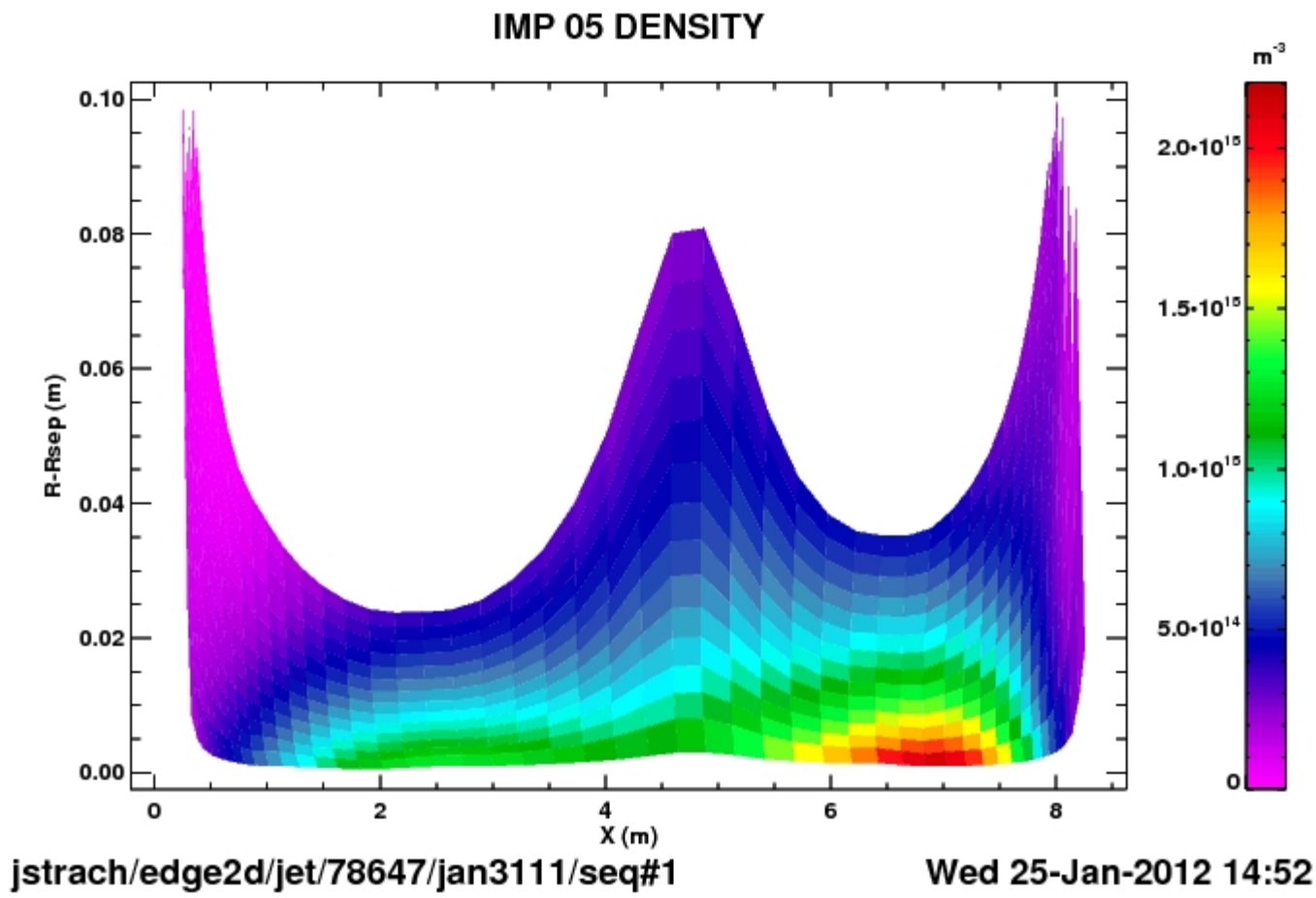
$W^{2+ \rightarrow 6+}$



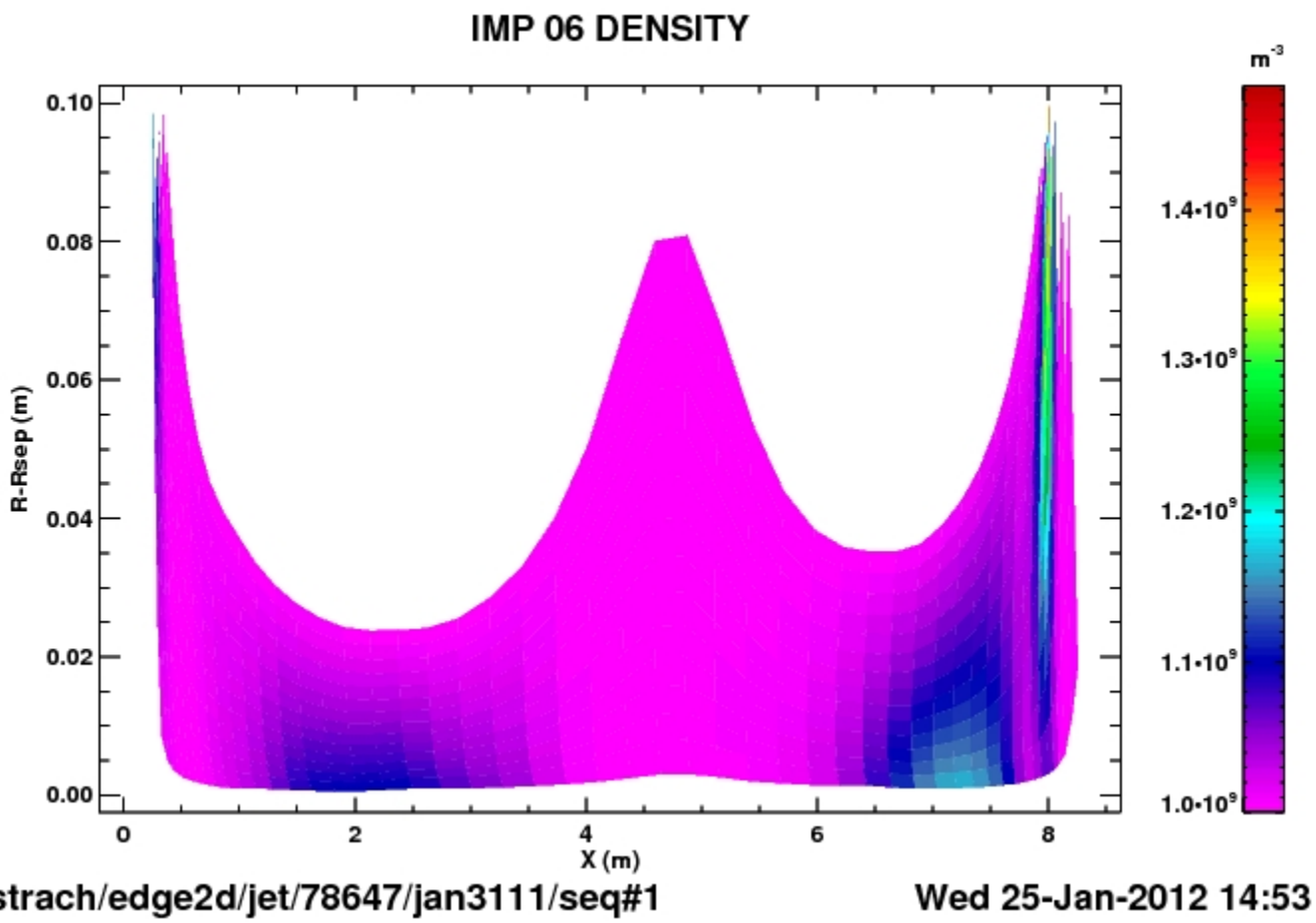
$W^{7+ \rightarrow 12+}$



W bundle $^{13+ \rightarrow 22+}$

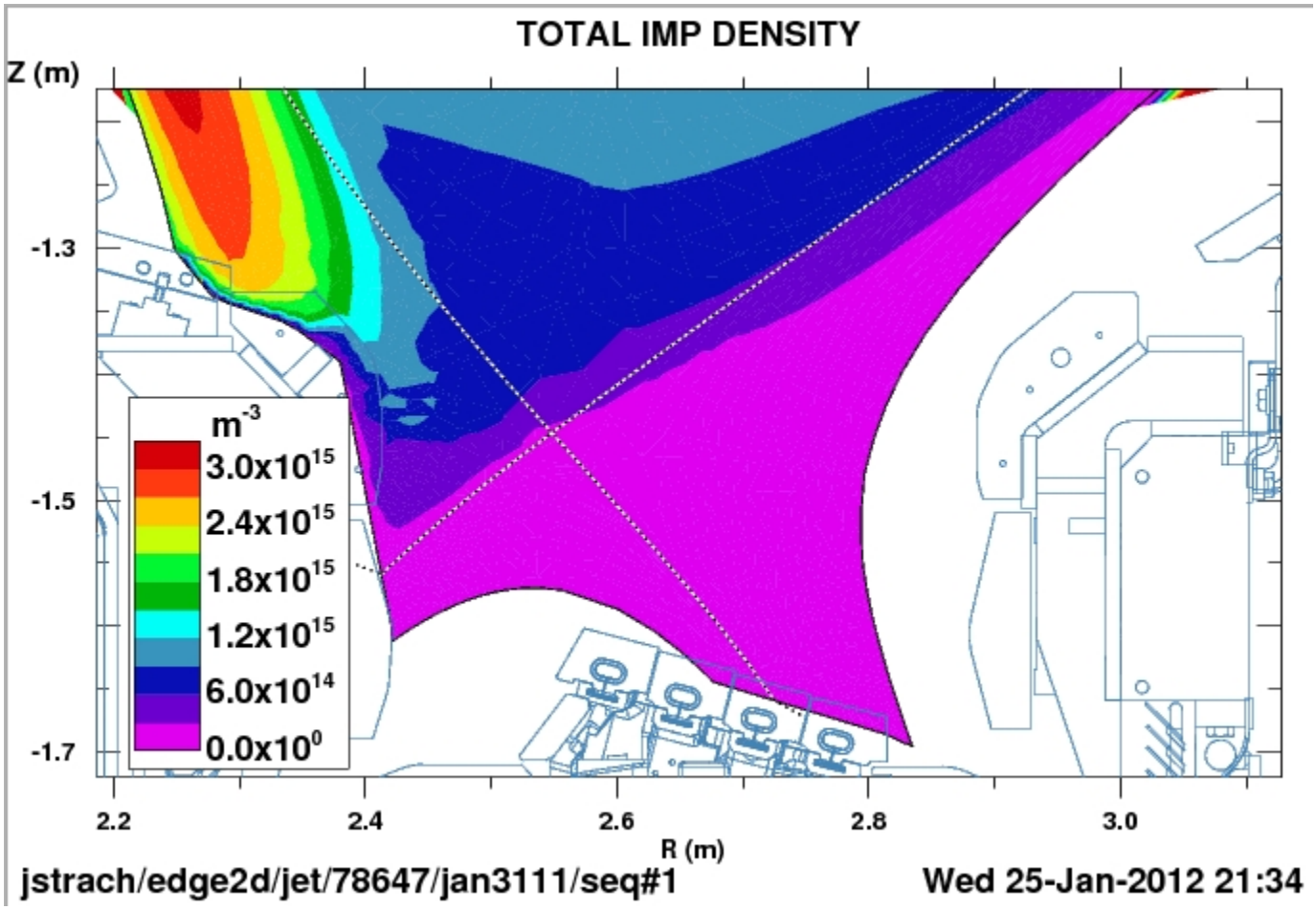


$W^{23+ \rightarrow 73+}$


IMP 06 DENSITY
m-3
1.4•10^9
1.3•10^9
1.2•10^9
1.1•10^9
1.0•10^9
R-Rsep (m)
0.10
0.08
0.06
0.04
0.02
0.00
0
2
4
6
8
X (m)
jstrach/edge2d/jet/78647/jan3111/seq#1
Wed 25-Jan-2012 14:53

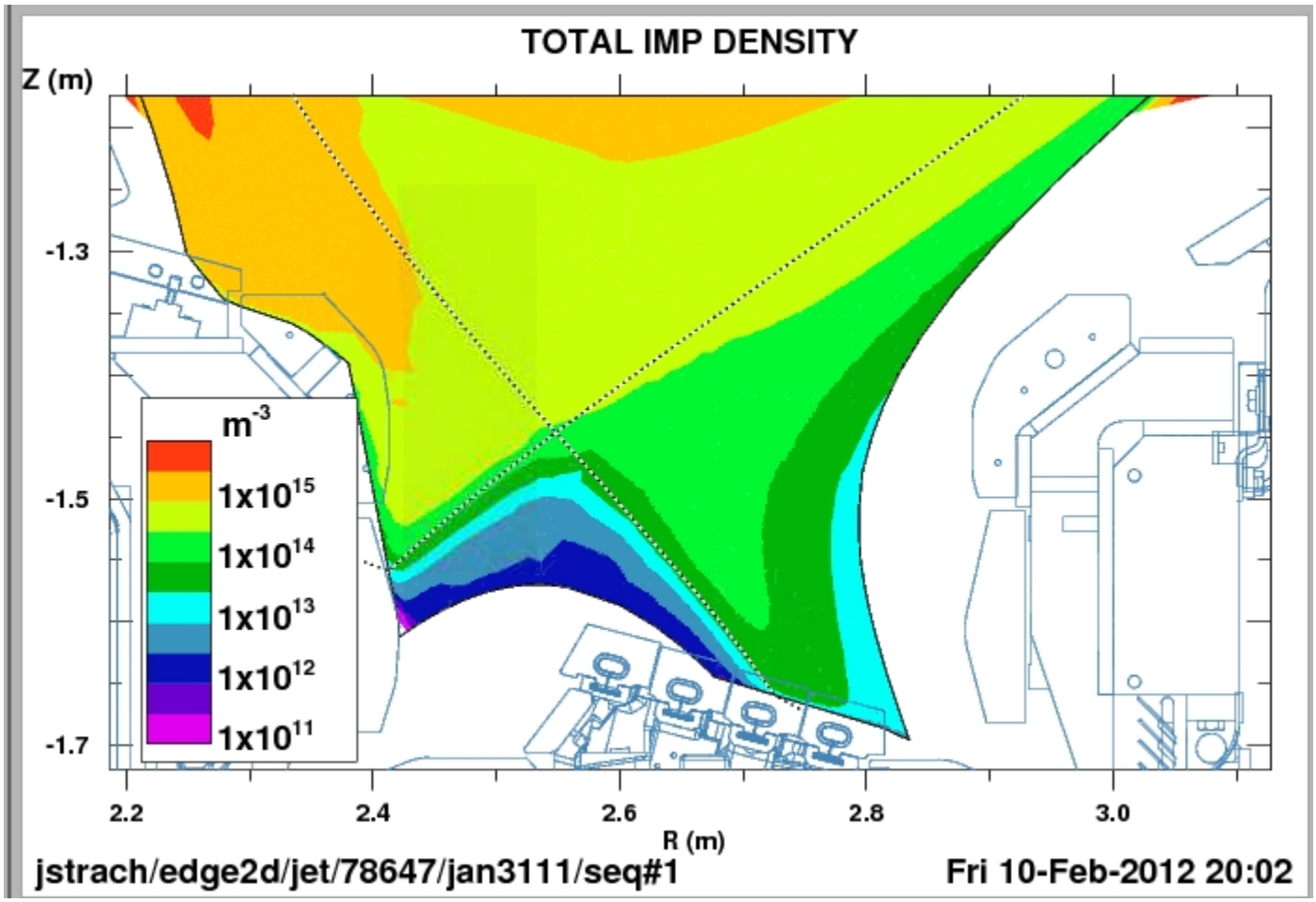
W^{74+}

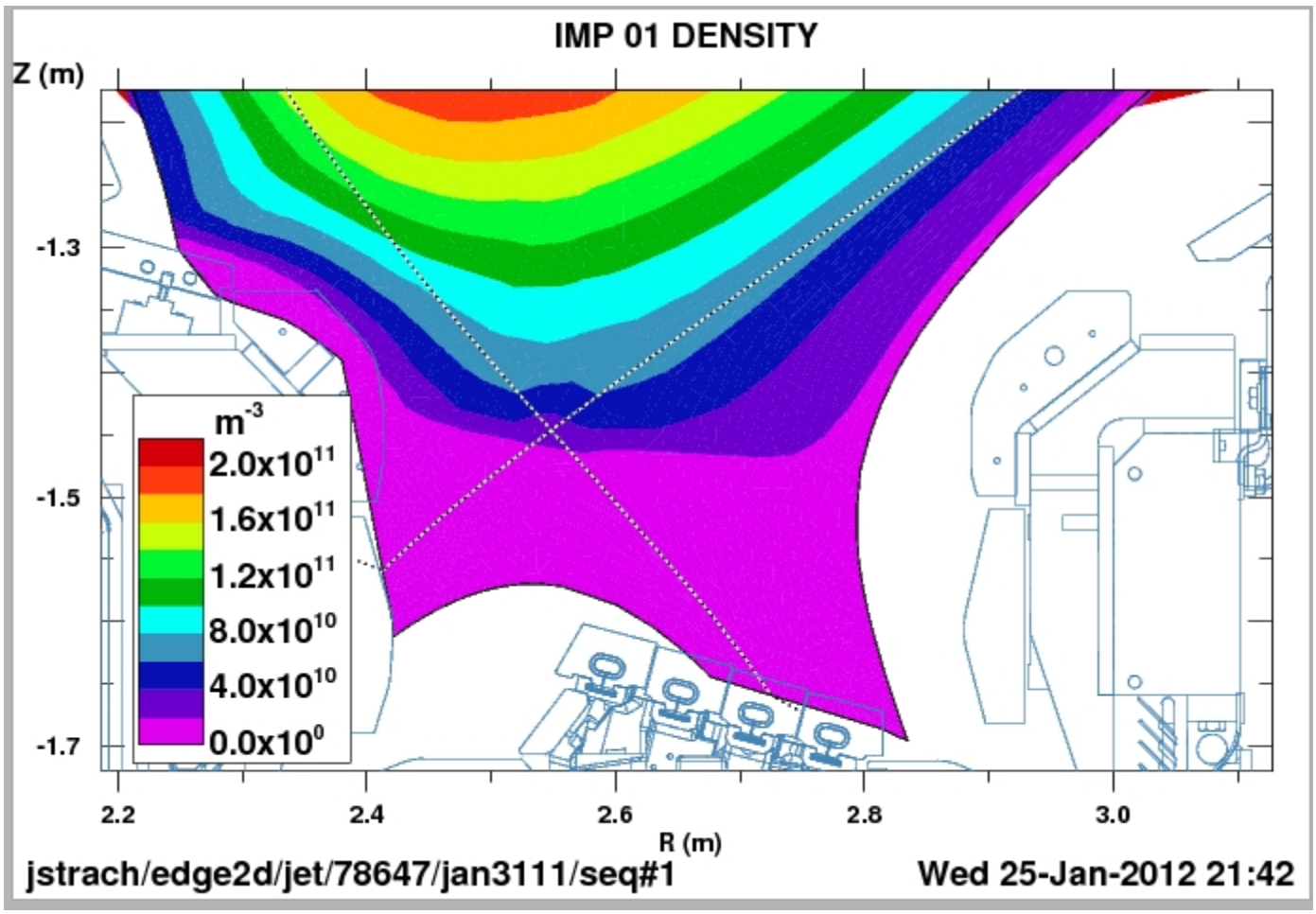
Puffing Case: Impurity densities, divertor view.



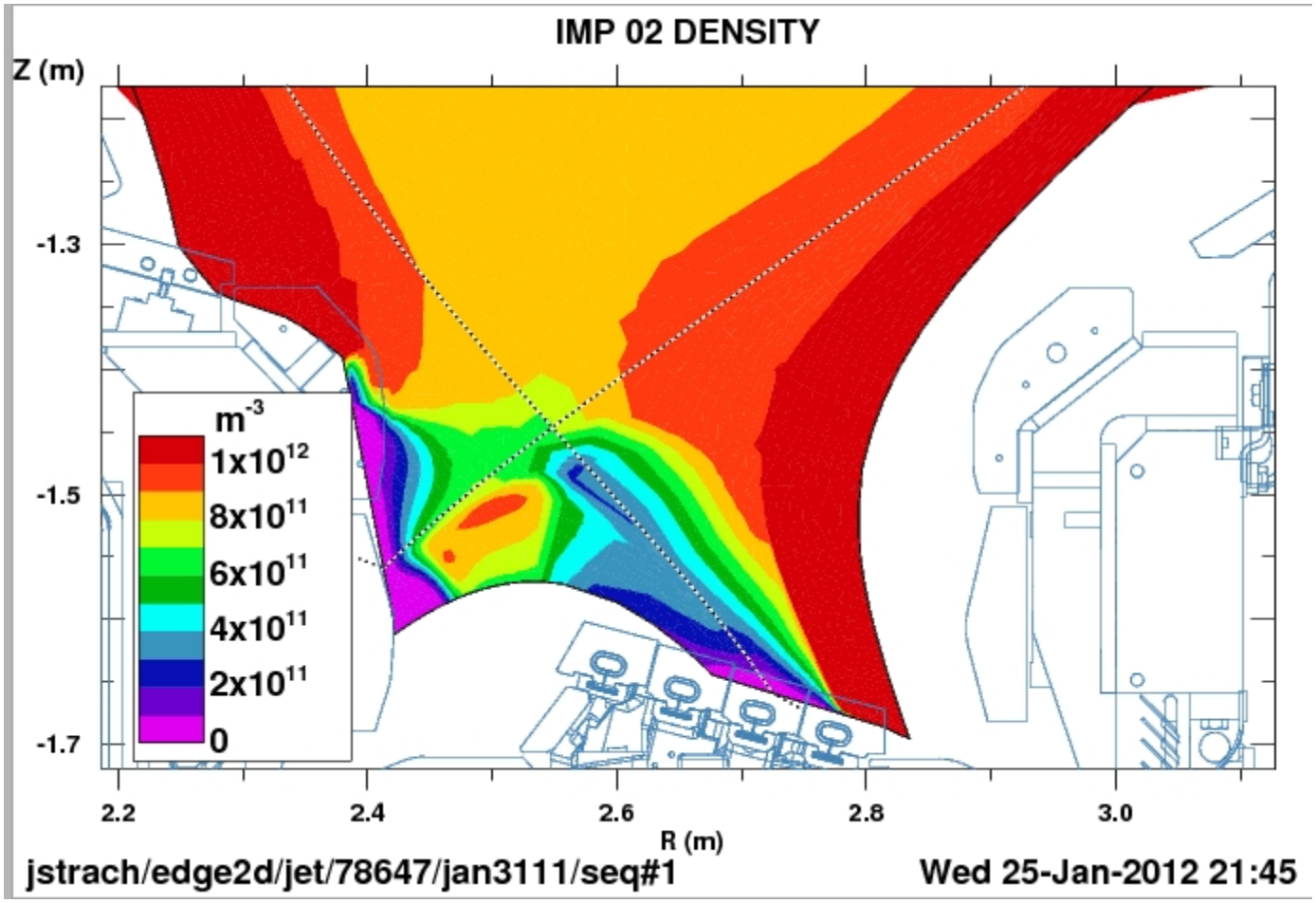
W Puffing from inner mid-plane on vessel. No Be in calculation.

On a Log scale:

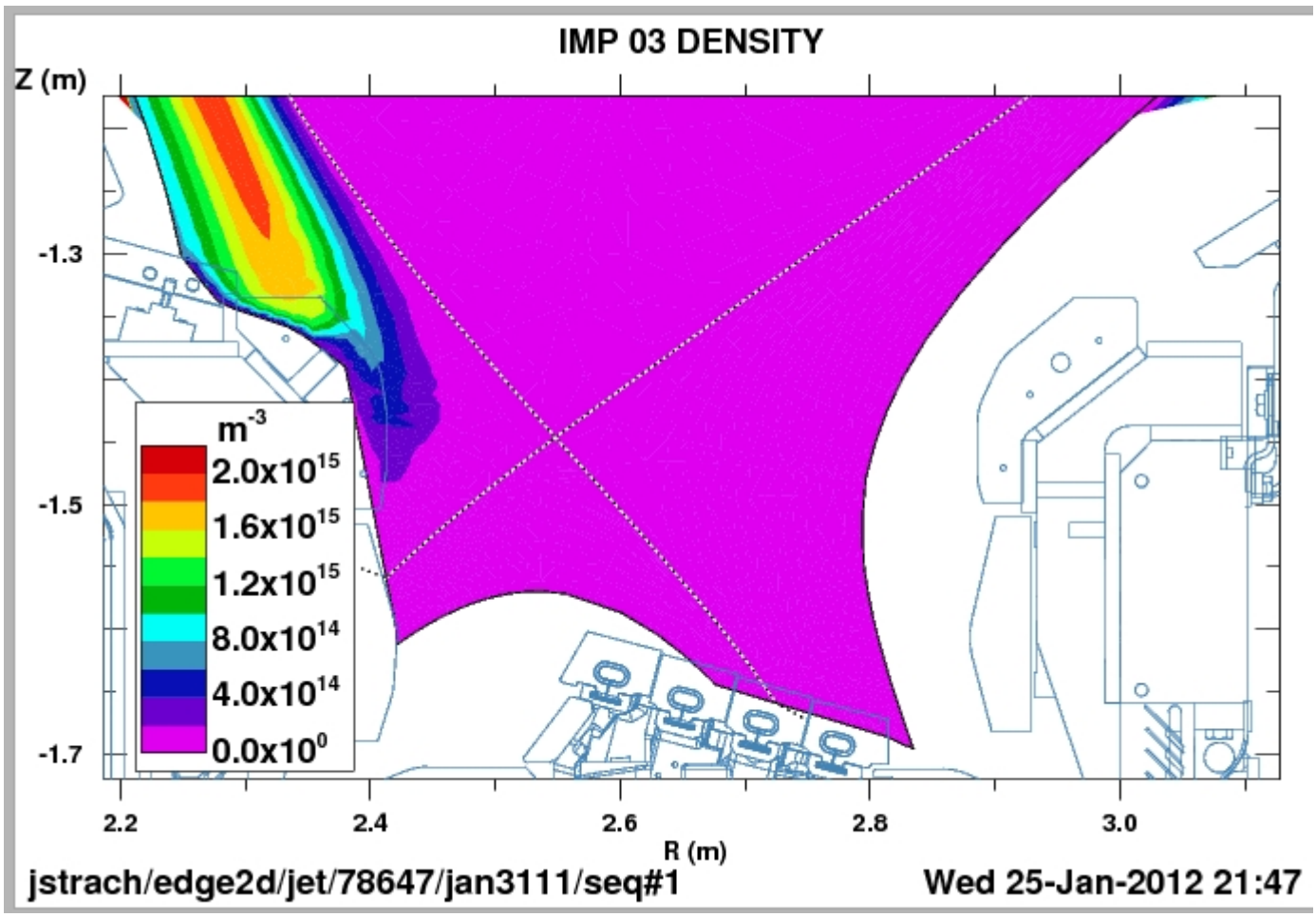



IMP 01 DENSITY
Z (m)
-1.3
-1.5
-1.7
m-3
2.0x10^11
1.6x10^11
1.2x10^11
8.0x10^10
4.0x10^10
0.0x10^0
2.2
2.4
2.6
2.8
3.0
R (m)
jstrach/edge2d/jet/78647/jan3111/seq#1
Wed 25-Jan-2012 21:42

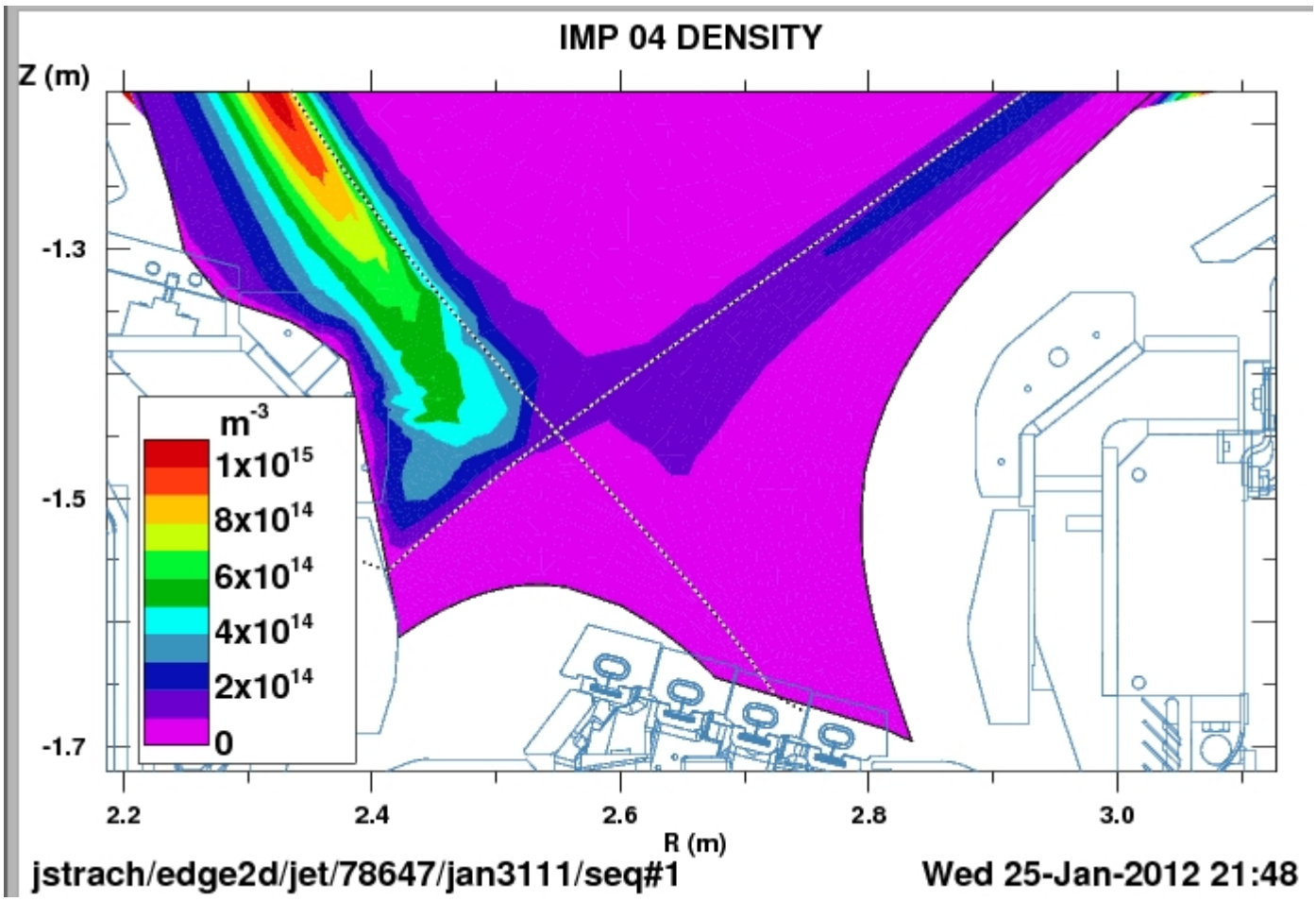
W^+



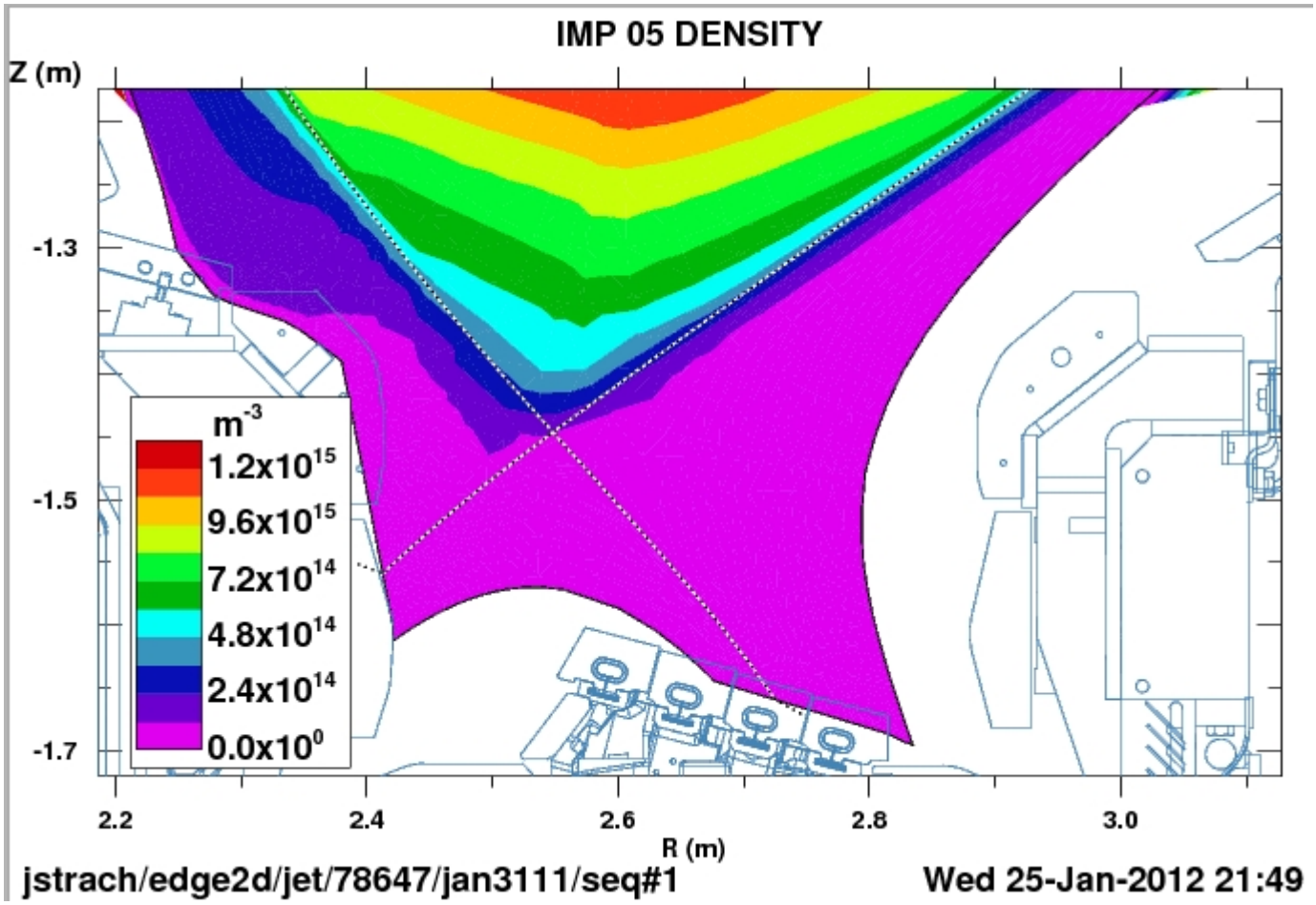
$W^{2+ \rightarrow 6+}$



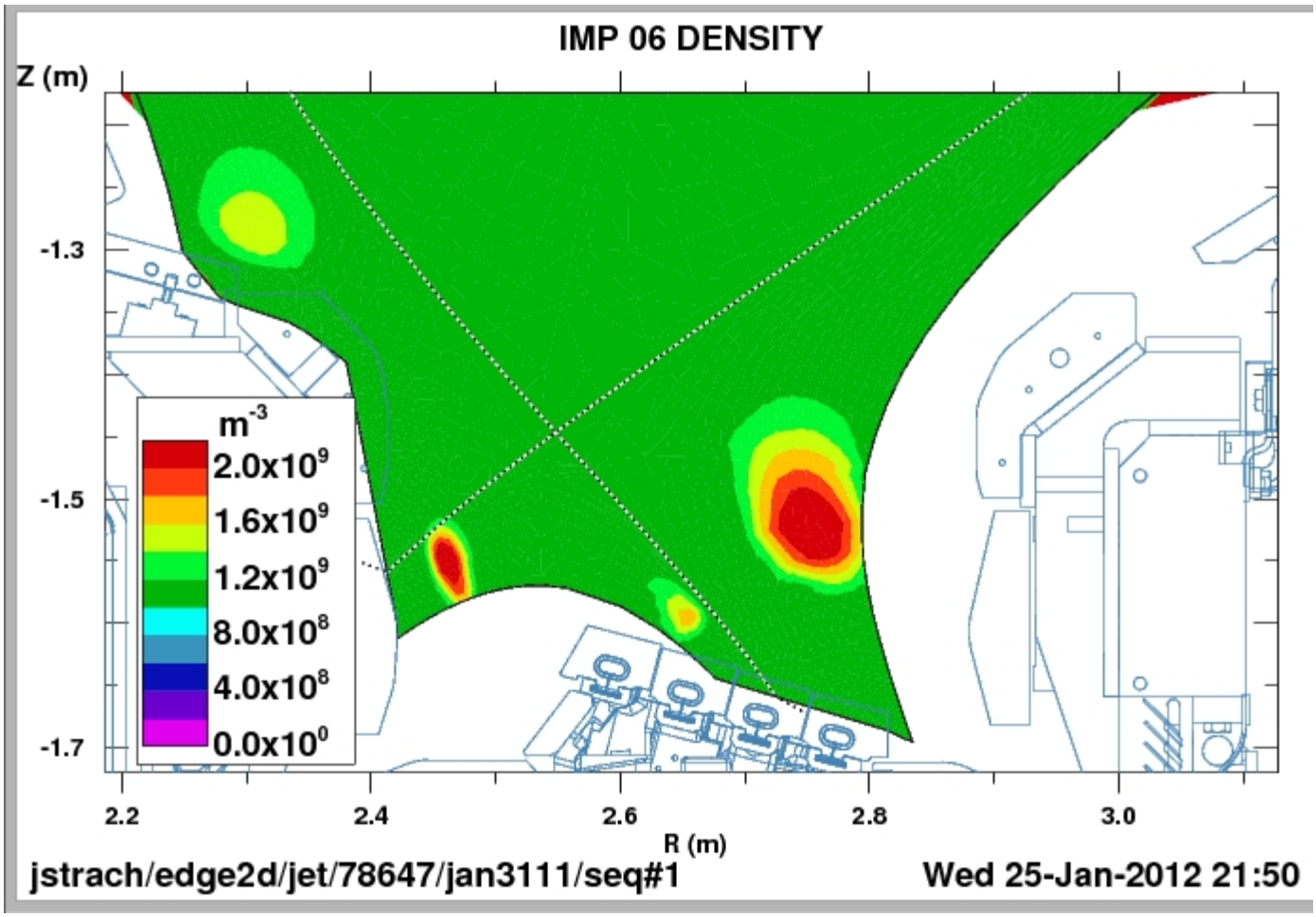
$W^{7+ \rightarrow 12+}$



W bundle $^{13+ \rightarrow 22+}$

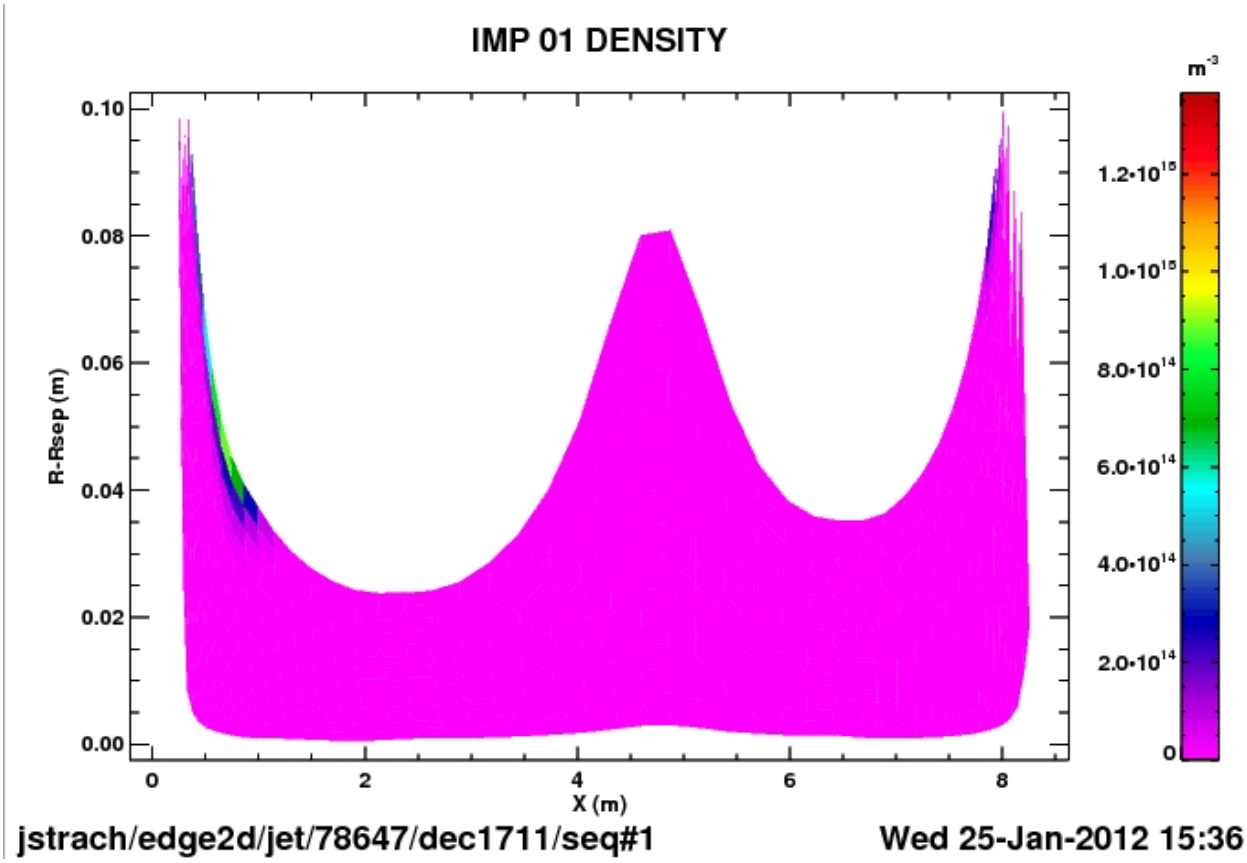


$W^{23+ \rightarrow 73+}$

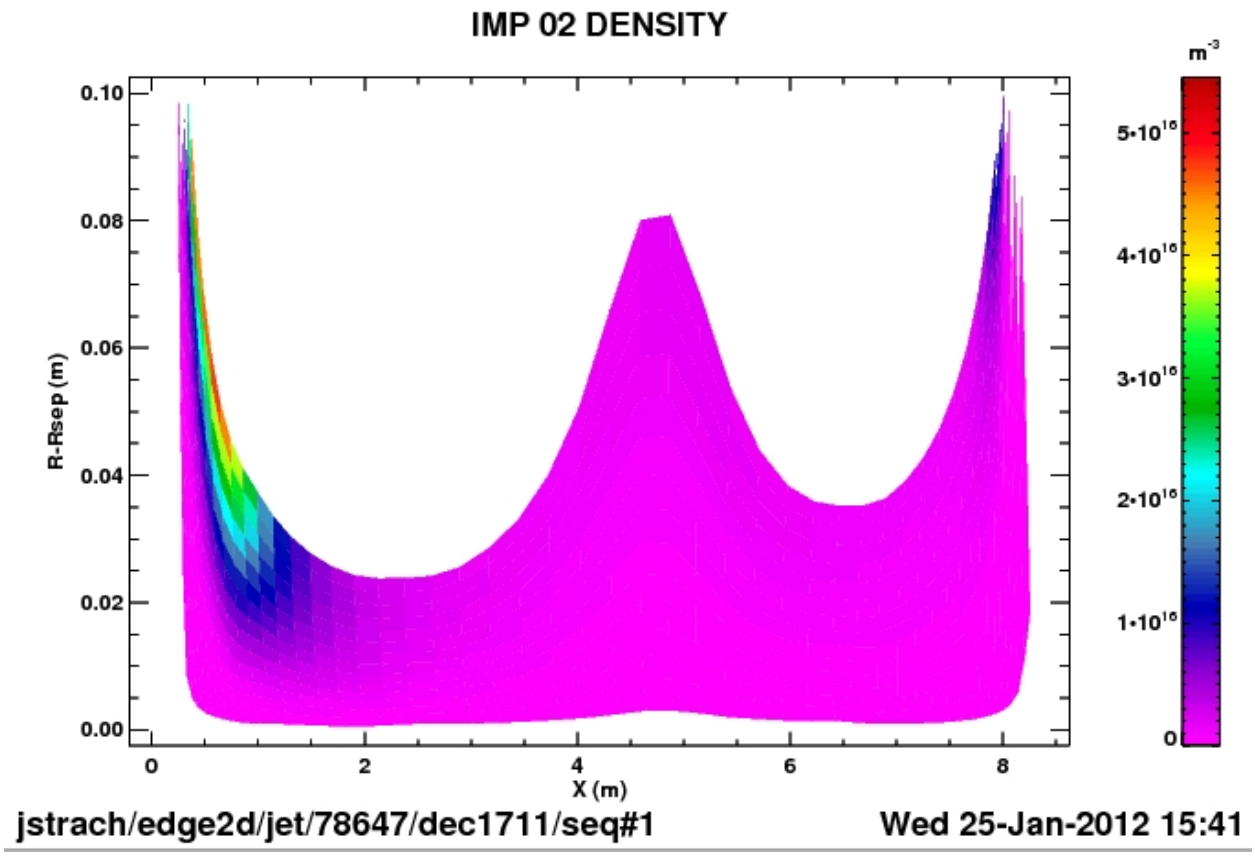

IMP 06 DENSITY
Z (m)
-1.3
-1.5
-1.7
m-3
2.0x10^9
1.6x10^9
1.2x10^9
8.0x10^8
4.0x10^8
0.0x10^0
2.2
2.4
2.6
2.8
3.0
R (m)
jstrach/edge2d/jet/78647/jan3111/seq#1
Wed 25-Jan-2012 21:50

W^{74+}

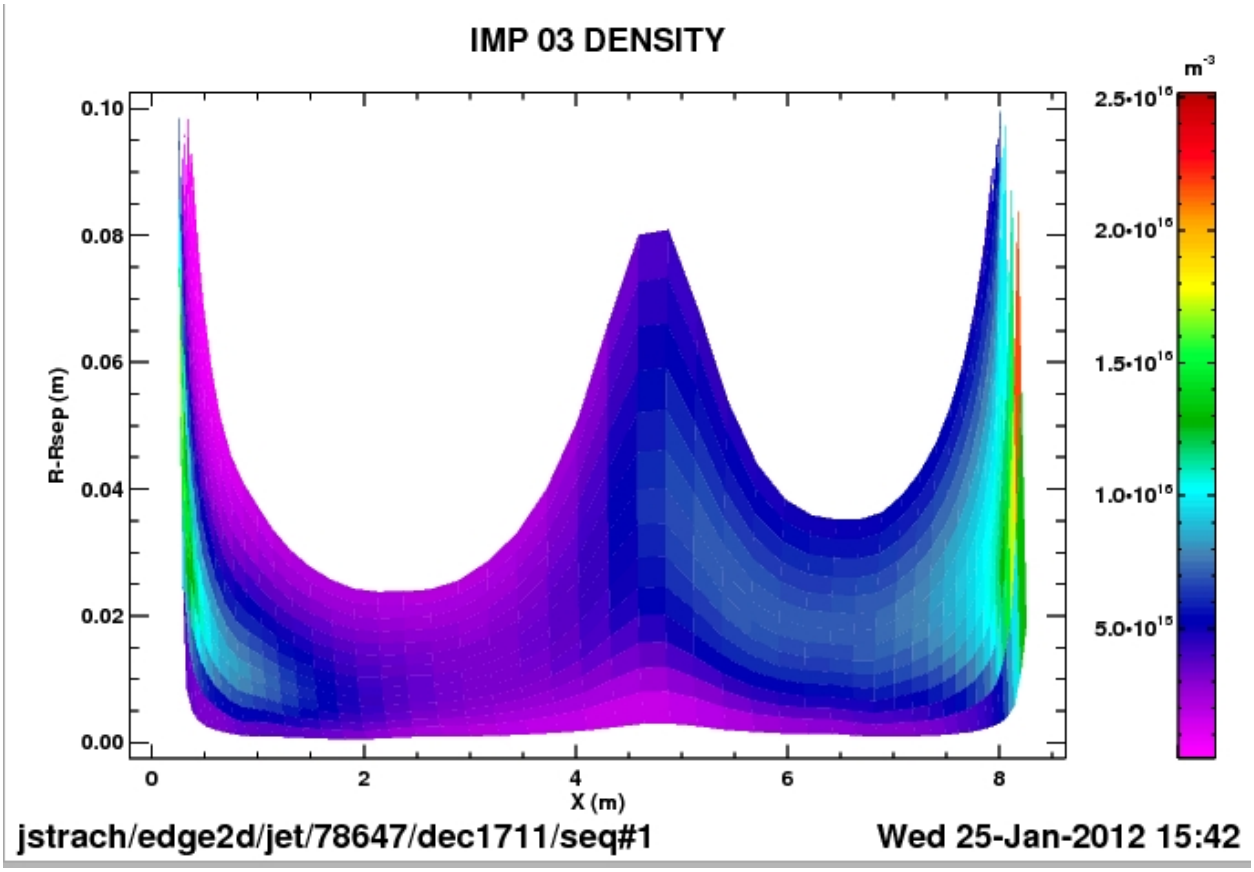
Between ELMs: Impurity densities, main chamber view.



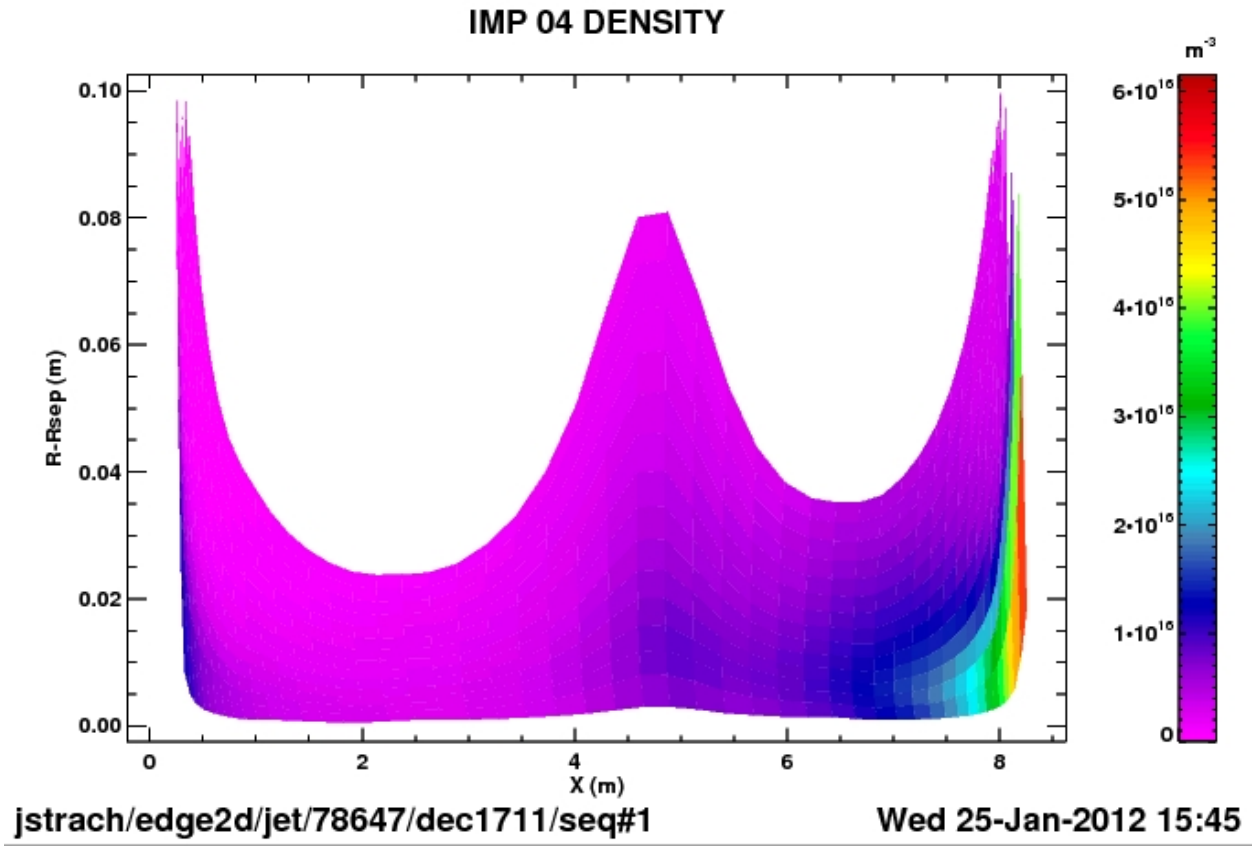
W^+ between ELMs



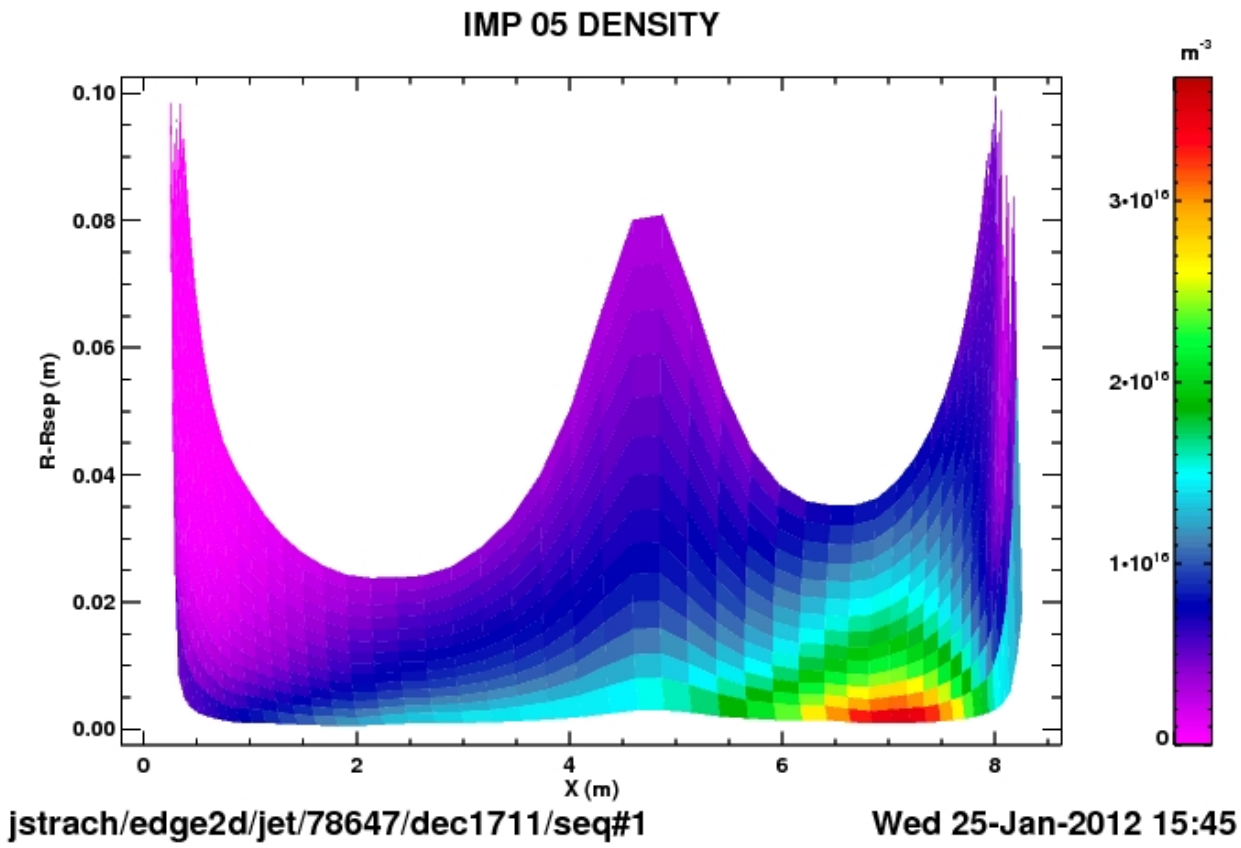
$W^{2+ \rightarrow 6+}$ between ELMs



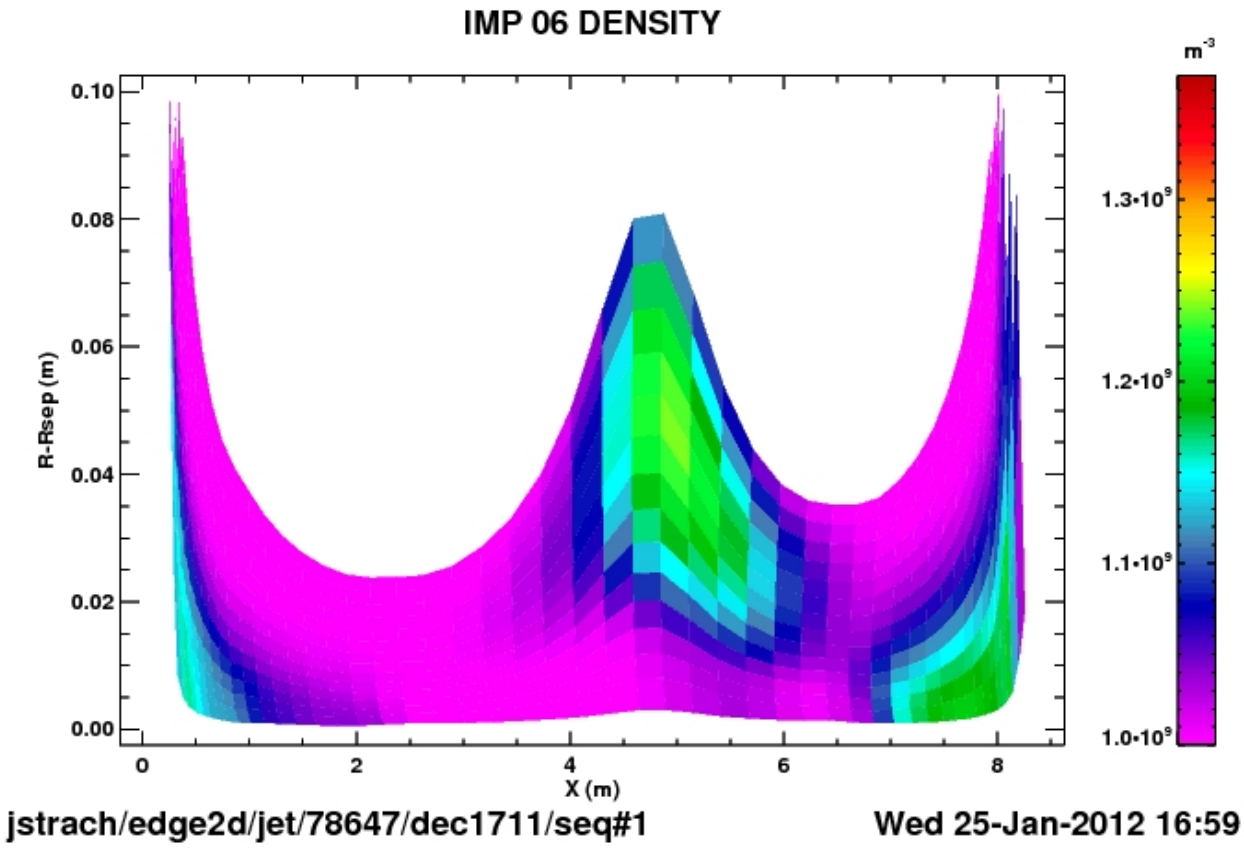
$W^{7+ \rightarrow 12+}$ between ELMs



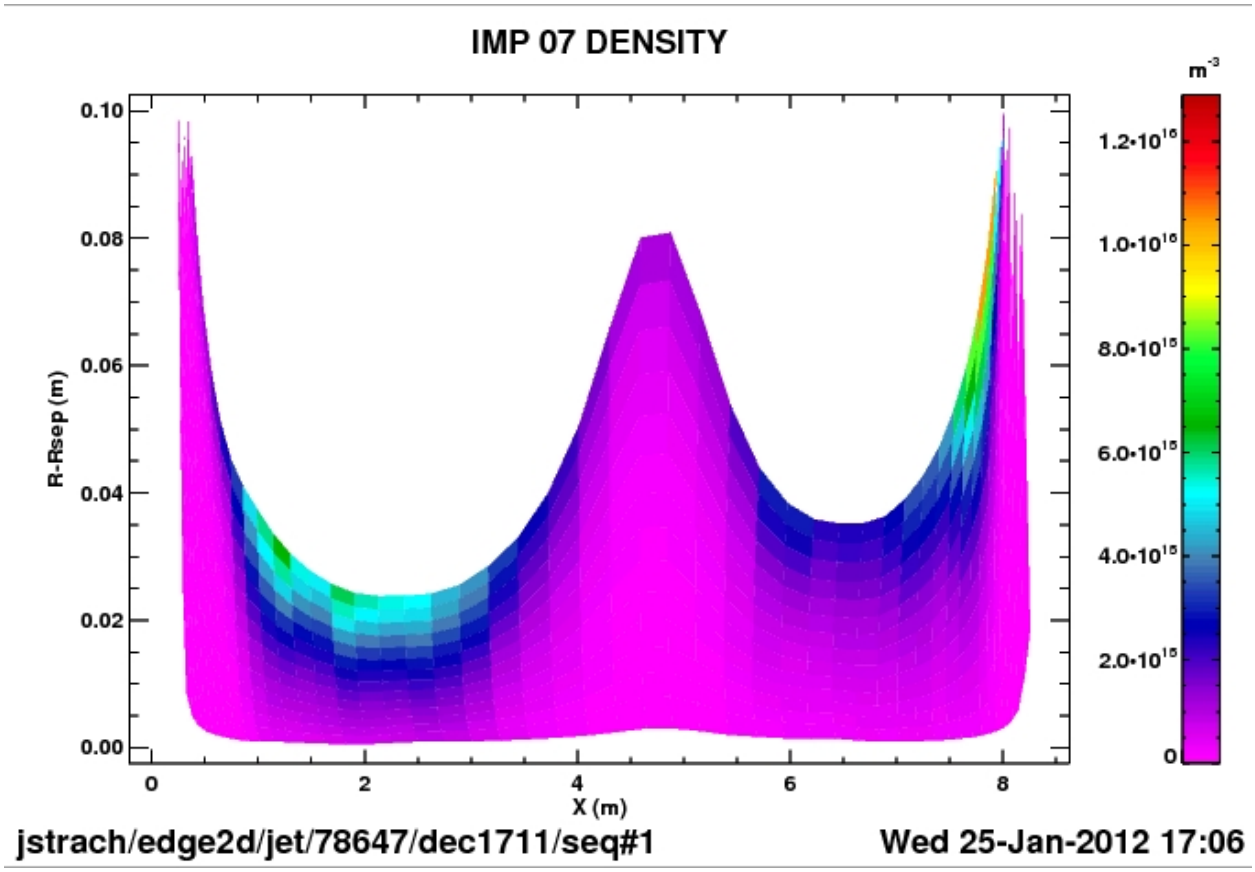
W bundle $^{13+ \rightarrow 22+}$ between ELMs



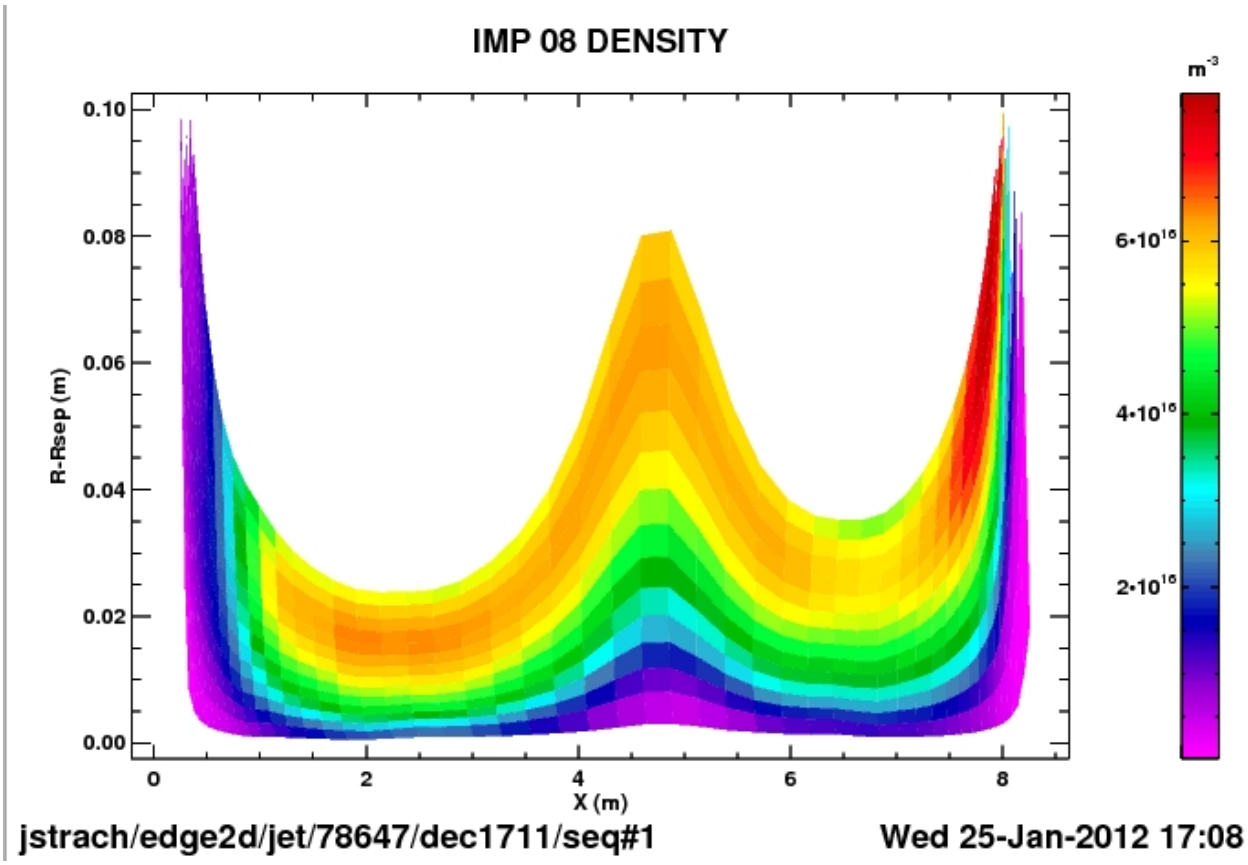
$W^{23+ \rightarrow 73+}$ between ELMs



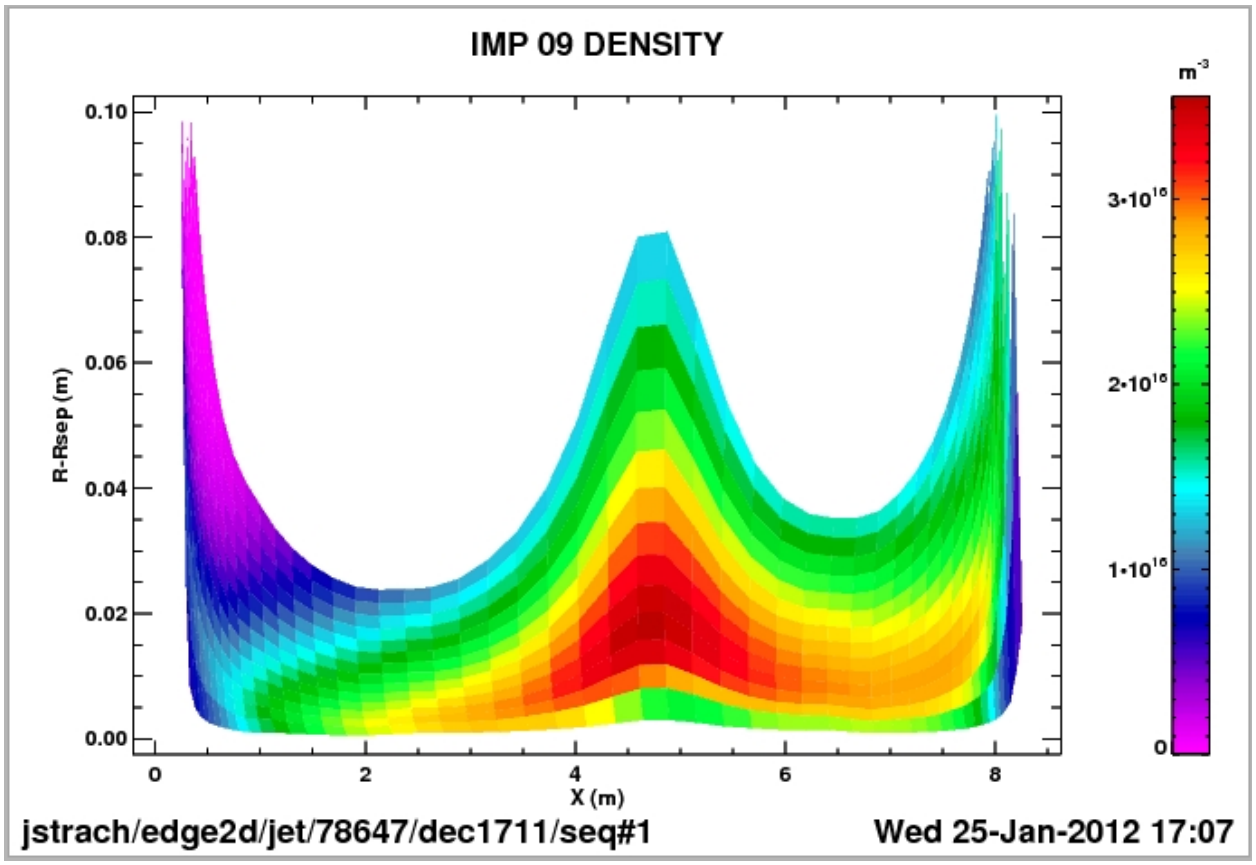
W^{74+} between ELMs



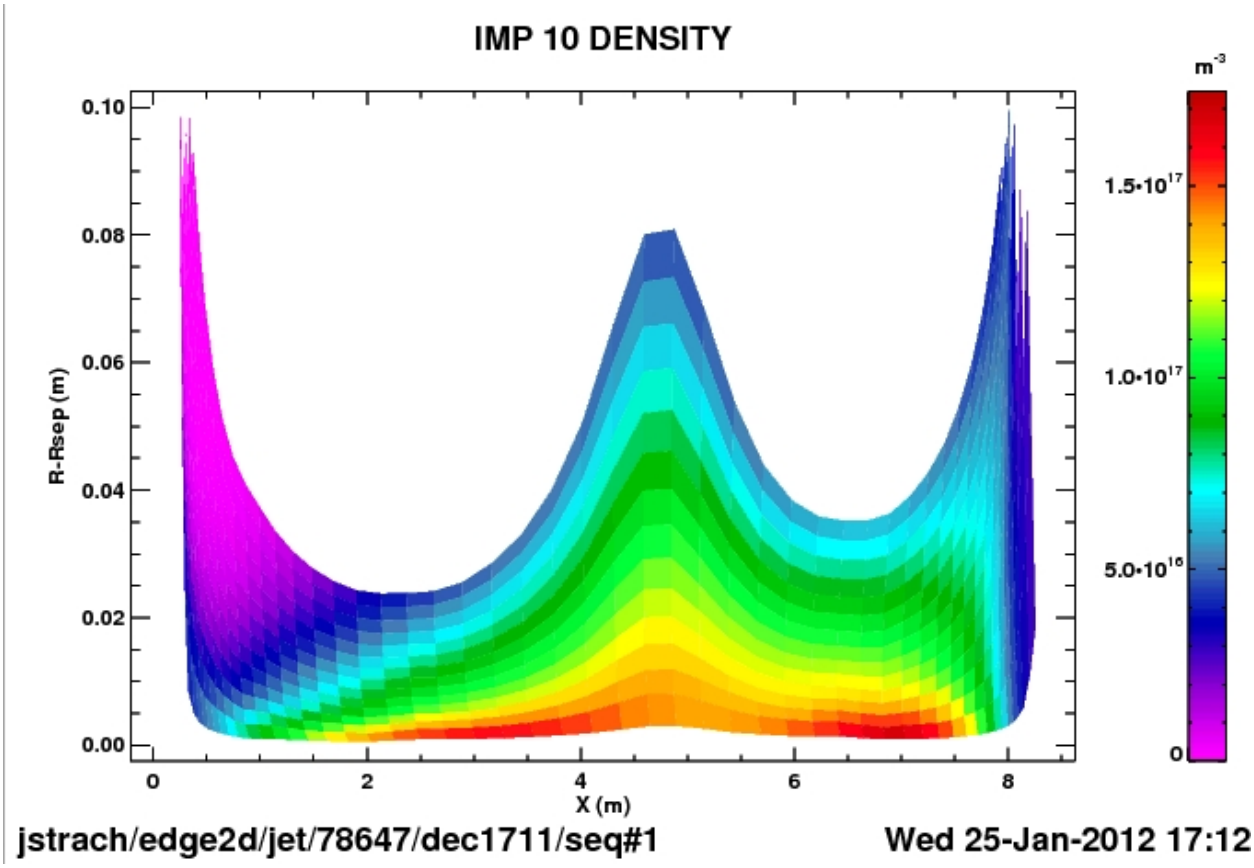
Be 1^{+} between ELMs



Be 2^{+} between ELMs

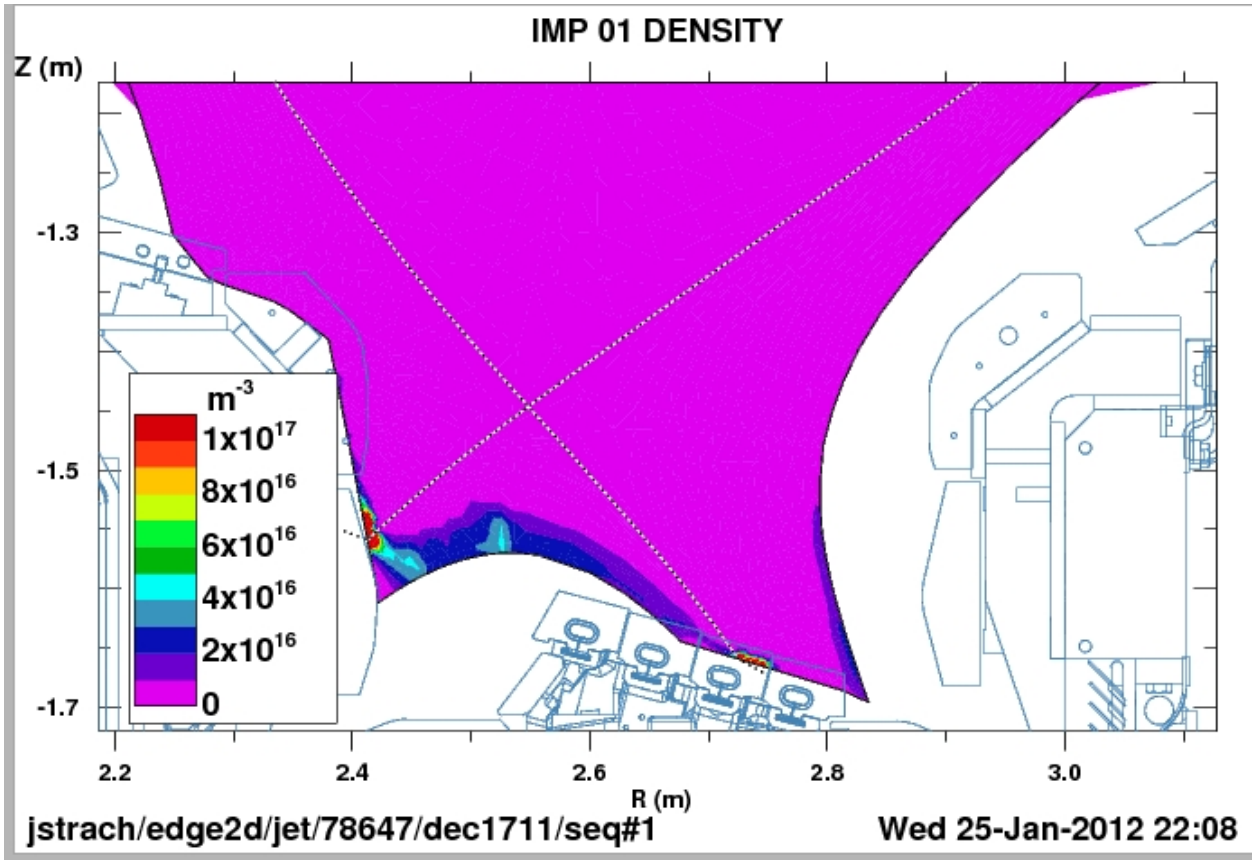


Be 3^{+} between ELMs

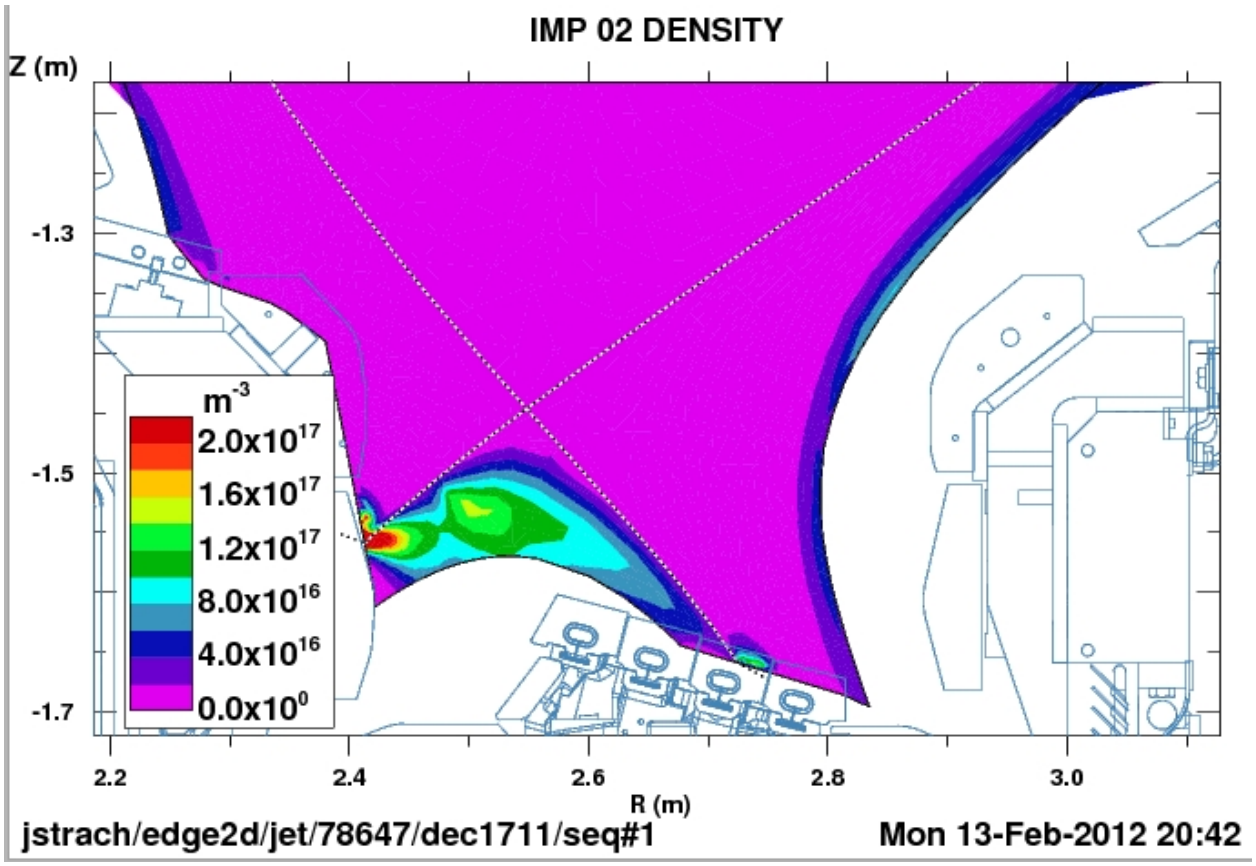


Be 4^{+} between ELMs

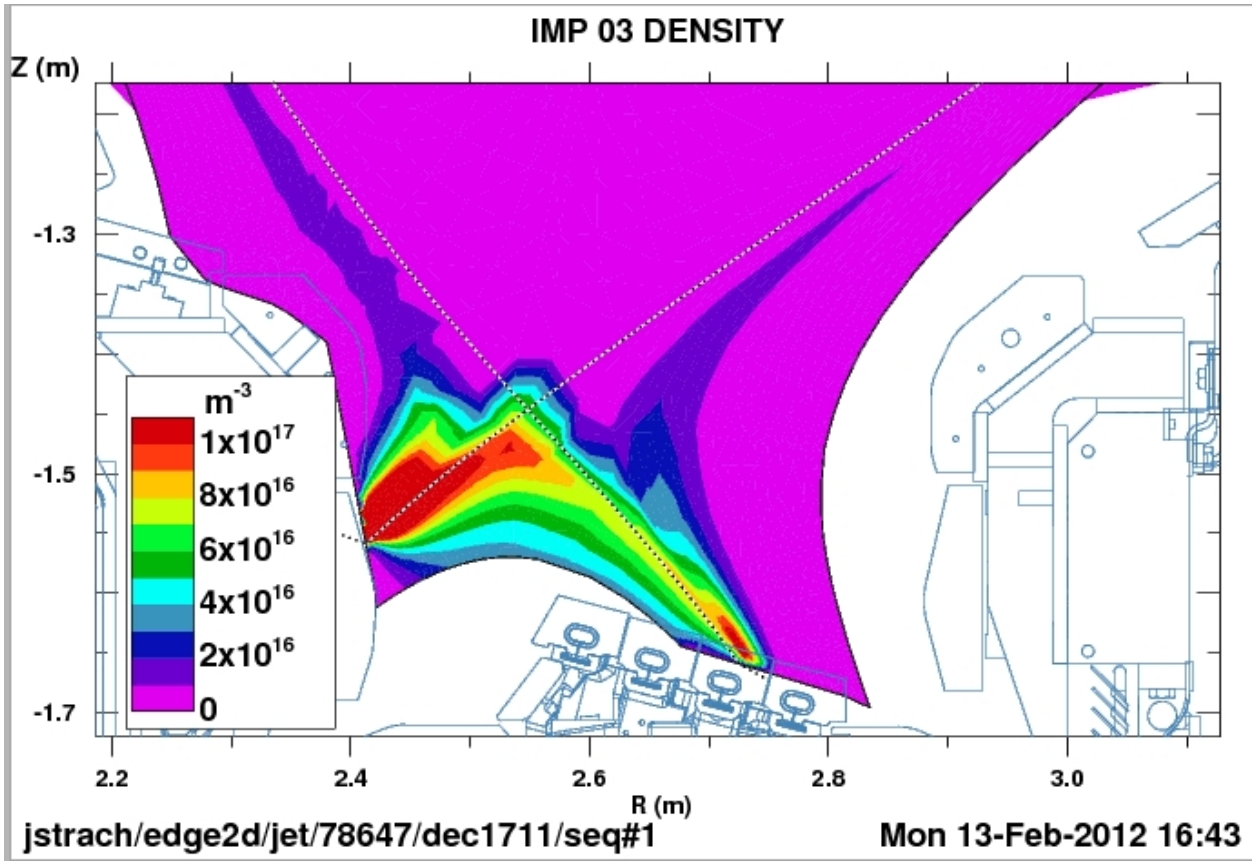
Between ELMs: Impurity densities, Divertor view.



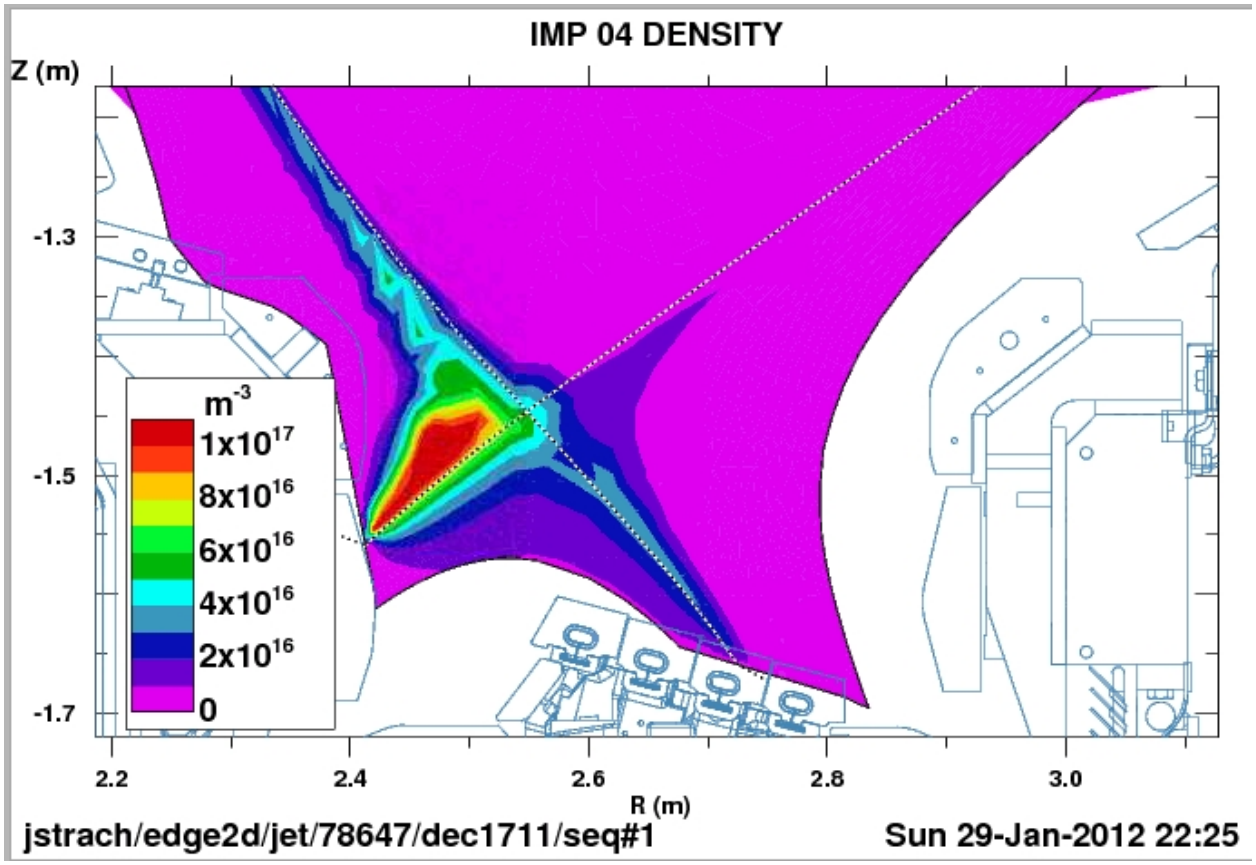
W^+ between ELMs



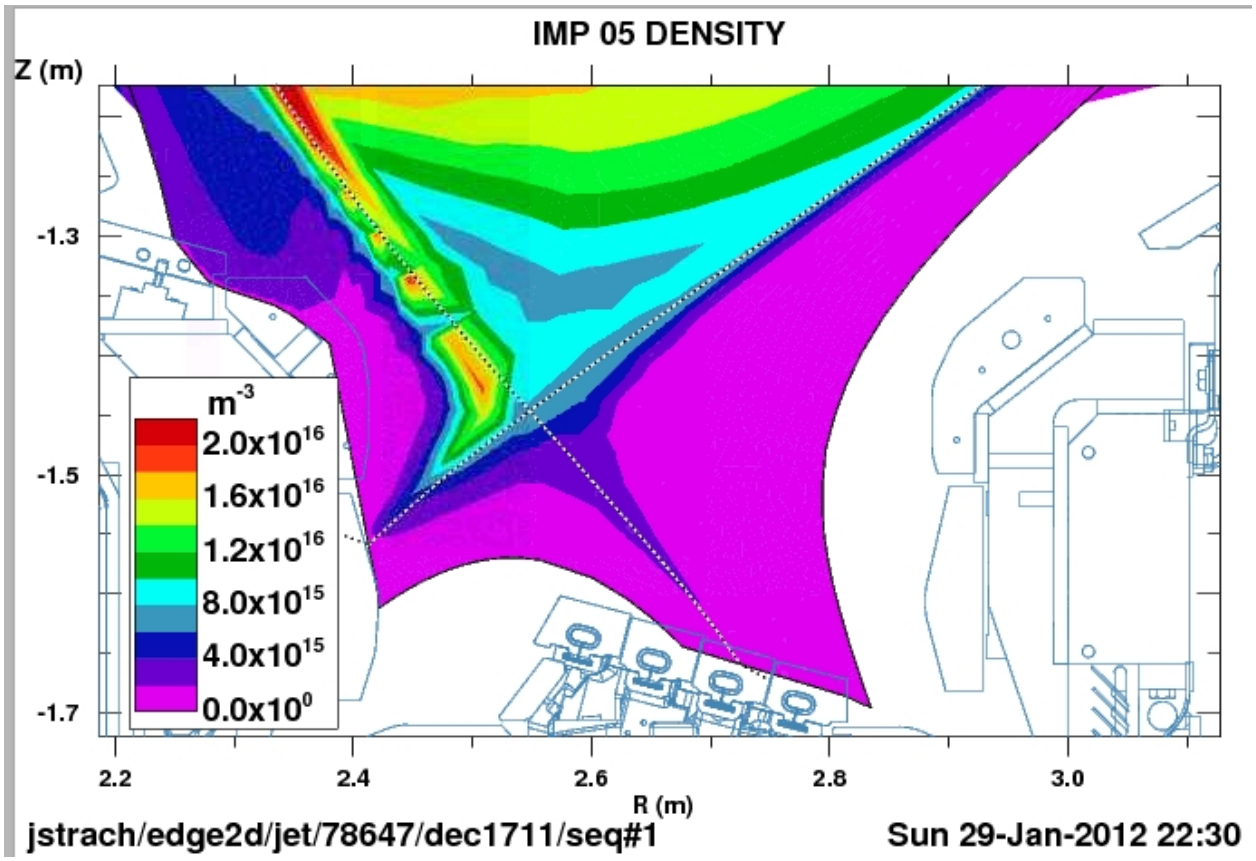
$W^{2+ \rightarrow 6+}$ between ELMs



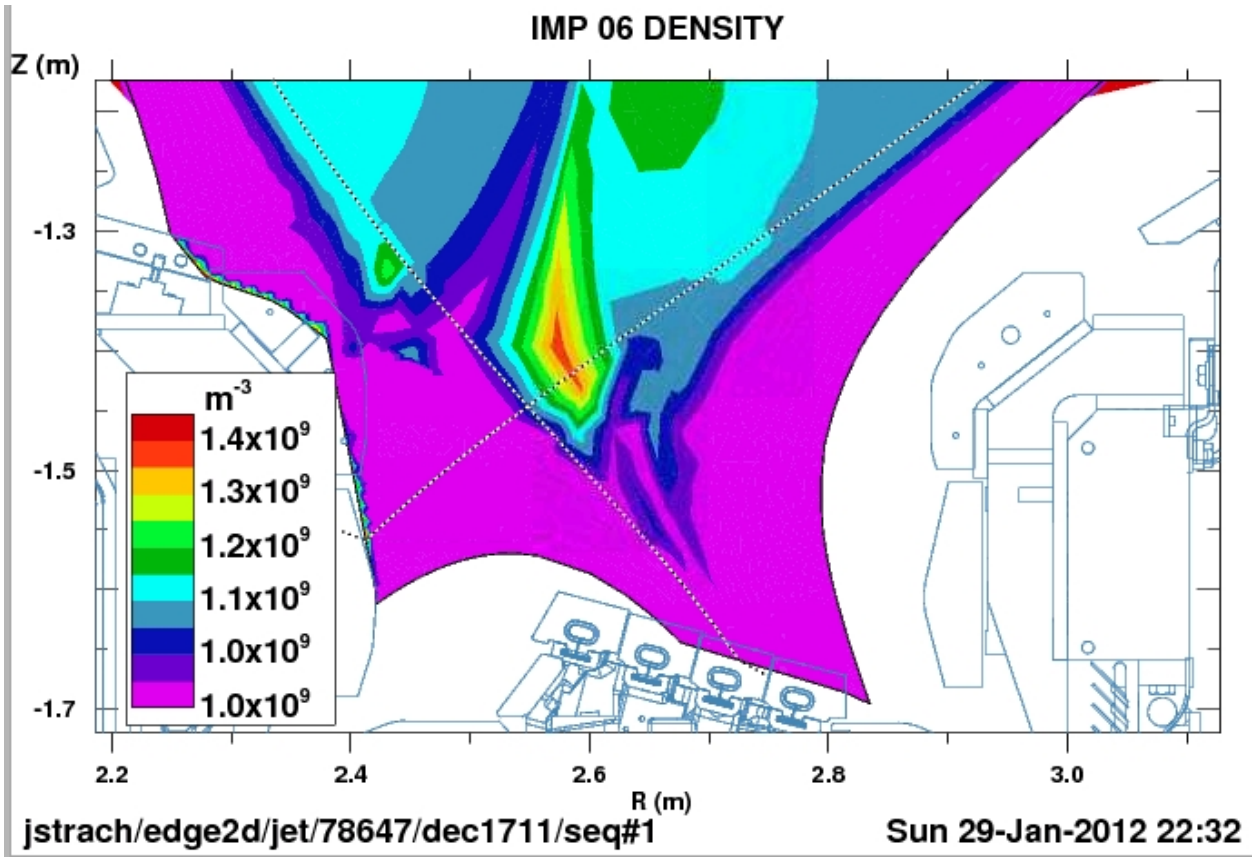
$W^{7+ \rightarrow 12+}$ between ELMs



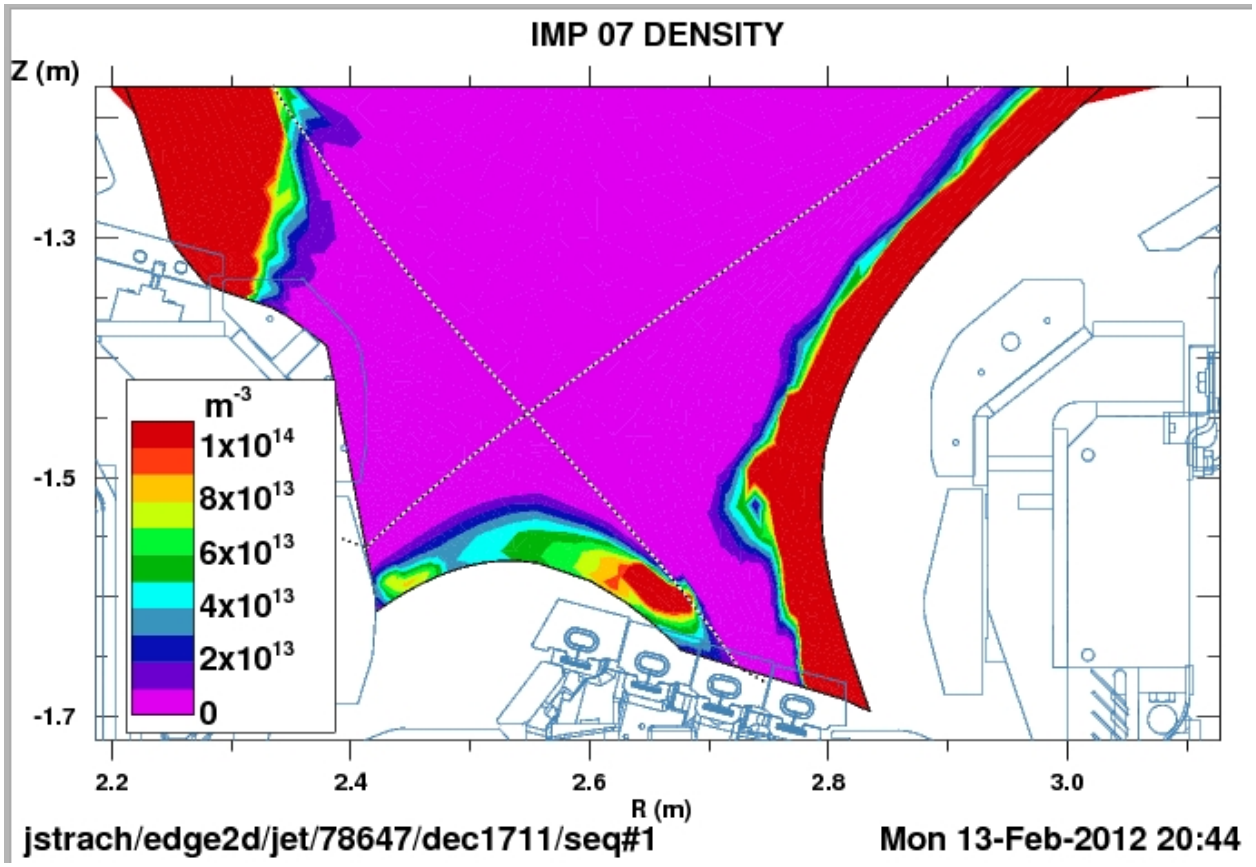
W bundle $^{13+ \rightarrow 22+}$ between ELMs



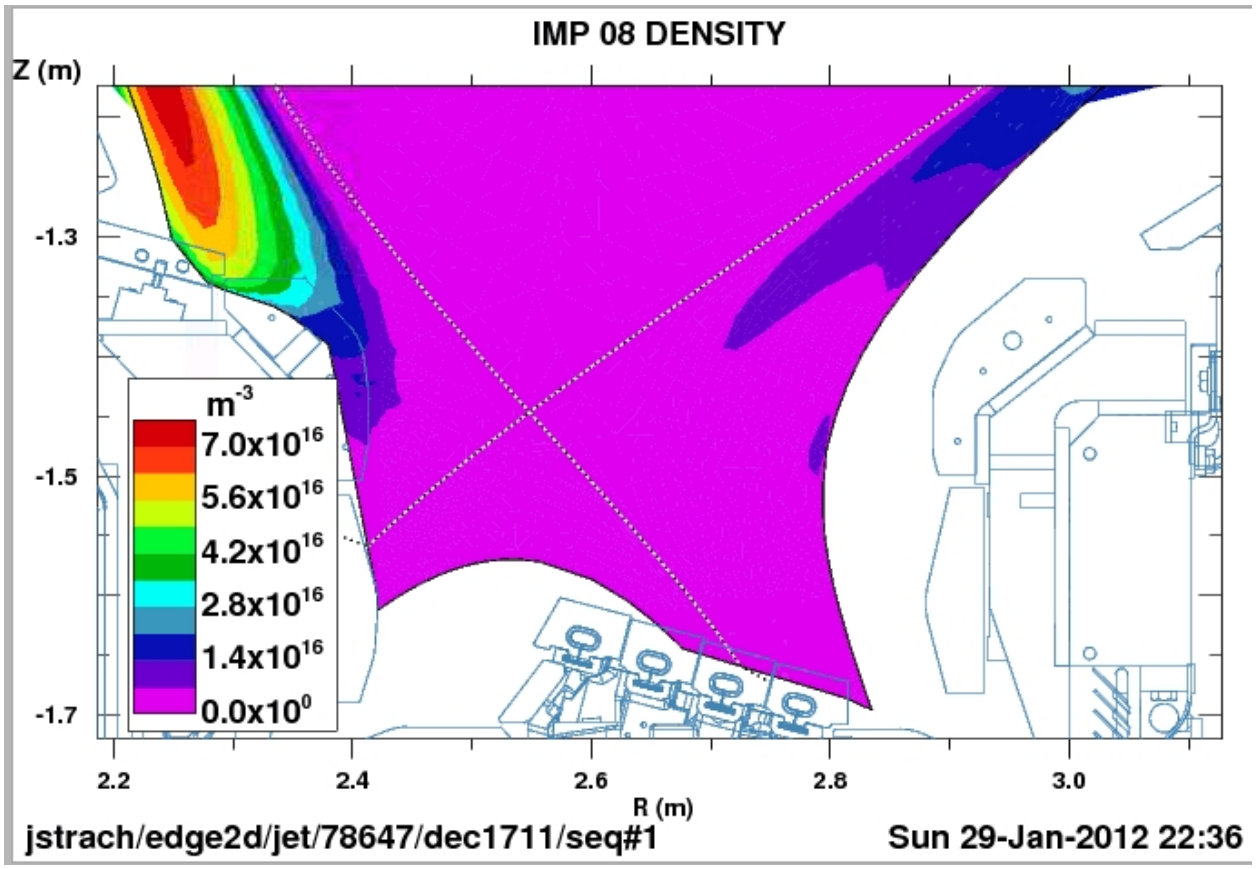
$W^{23+ \rightarrow 73+}$ between ELMs



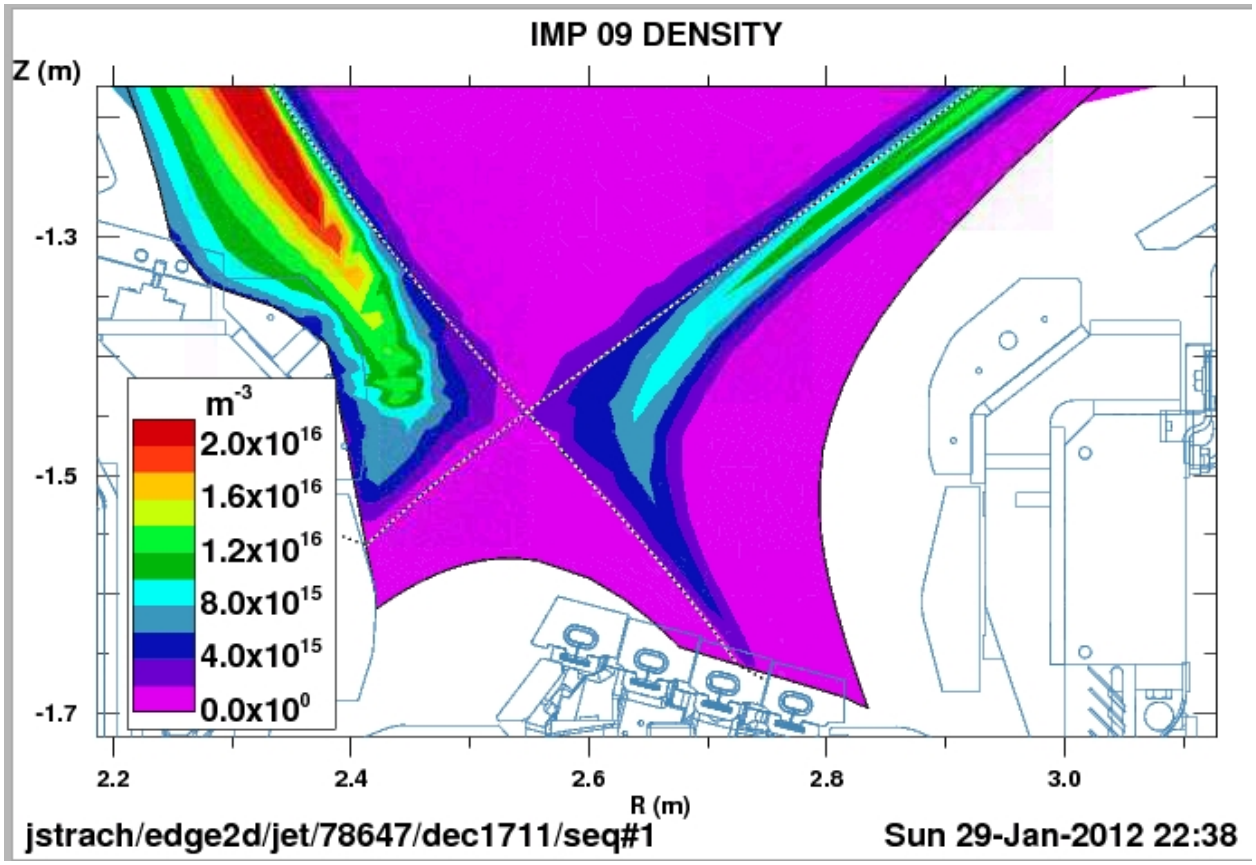
W^{74+} between ELMs



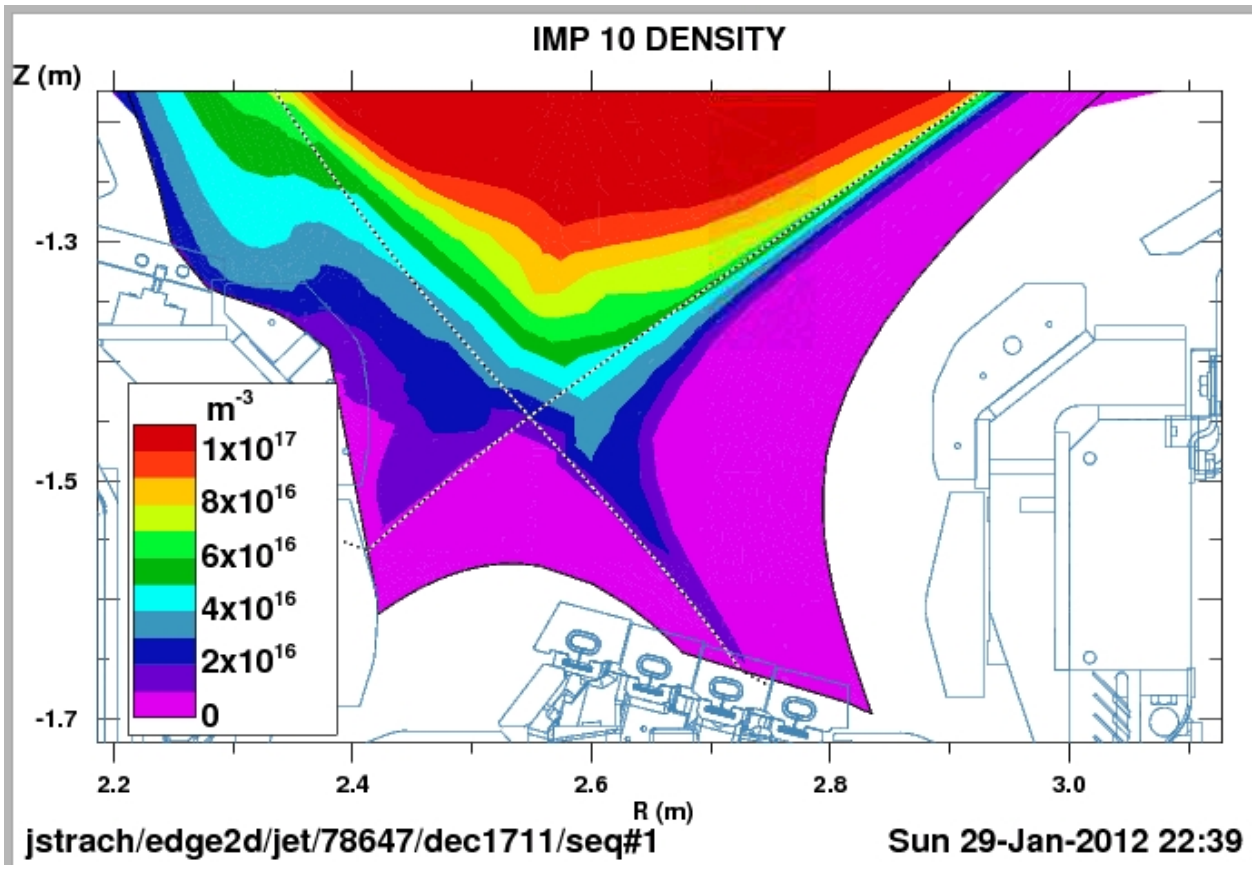
Be 1^{+} between ELMs



Be 2^{+} between ELMs



Be 3^{+} between ELMs



Be 4^{+} between ELMs

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