

Updates on magnetic footprint reader for Juno and Jovian moons at UI

Masafumi Imai

University of Iowa

(Apr 12 2019)

- Magnetic footprints for Juno and Jovian moons (Amalthea, Io, Europa, Ganymede, and Callisto) and Juno's M-value are computed using JRM09 [Connerney+, 2018] and current sheet models [Connerney+, 1981] when Juno is within $15 R_J$ from the center of the planet.
- All of the data from Juno's perijove 0 through 34 are computed with IDL programs at University of Iowa (UI), and stored in the hdf5 format; these computations are regularly performed with the recent Juno SPICE kernels (i.e. ~ 1 -2 month after each perijove).
- The original hdf5 files and IDL reader for these files are available at <http://space.physics.uiowa.edu/juno/mwg/magfootprint.html> (Juno MWG website at UI). If you have questions and requests, please direct to masafumi-imai@uiowa.edu
- In the recent version, I added the following variables for each perijove data.
 - FootB0UV and JunoB0 (Modeled B0 at Juno's footprint and instantaneous position at given time)
 - EqWLon and EqLat (Juno's magnetic field line crossing with the JRM09-dipole magnetic equator)
 - MagEqWLon and MagEqLat (EqWLon and EqLat in Jovimagnetic coordinates)
 - NorthFootWlonUV, NorthFootLatUV, NorthFootB0UV, NorthJunoFieldLineLengthUV (Juno's footprint information on northern hemisphere)
 - SouthFootWlonUV, SouthFootLatUV, SouthFootB0UV, SouthJunoFieldLineLengthUV (Juno's footprint information on southern hemisphere)

Jovian 1-bar level surface

- Latitude-dependent distance from the center of Jupiter at 1-bar level is computed as follows.

$$\left| \frac{R_J / \cos \lambda}{\sqrt{1 + (\tan \lambda)^2 / (1 - f)^2}} \right|$$

where $f = (71492 - 66854) / 71492$, $R_J = 71492$ km, and λ is Jovicentric latitude in radian.

- Please note that this expression is an approximation and valid in the order of tens of km because the shape of Jupiter is like a diamond (Buccino et al., AGU Fall Meeting, 2018). Because of this, there is a slight discrepancy between the above value and the Galileo Probe's measurement at 1-bar level (Seiff et al., JGR, 1998). Nevertheless, I use the above equation to compute Jovian 1-bar level surface.

Coordinate System for VIP4- and JRM09-based dipoles

Offset dipole
configuration

VIP4-based dipole

JRM09-based dipole

Magnetic tilt colatitude θ_0

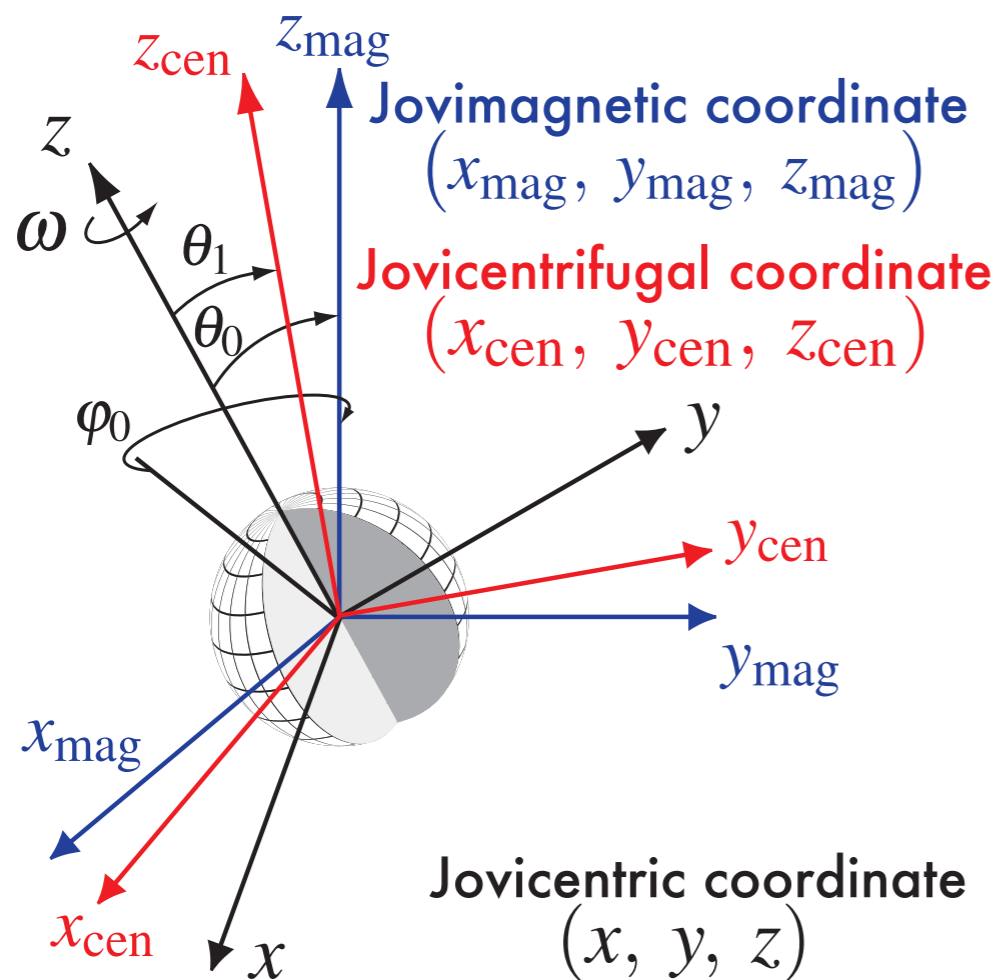
9.52°

10.31°

West longitude ϕ_0

200.77°

196.61°



According to Chapman & Bartels (1940), the transformation forms may be written as:

$$\theta_0 = \arccos \left(\frac{g_1^0}{\sqrt{(g_1^0)^2 + (g_1^1)^2 + (h_1^1)^2}} \right)$$

$$\phi_0 = \arctan \left(\frac{h_1^1}{g_1^1} \right)$$

Coordinate System for VIP4- and JRM09-based dipoles

Offset dipole configuration

VIP4-based dipole

JRM09-based dipole

Magnetic tilt colatitude θ_0

9.52°

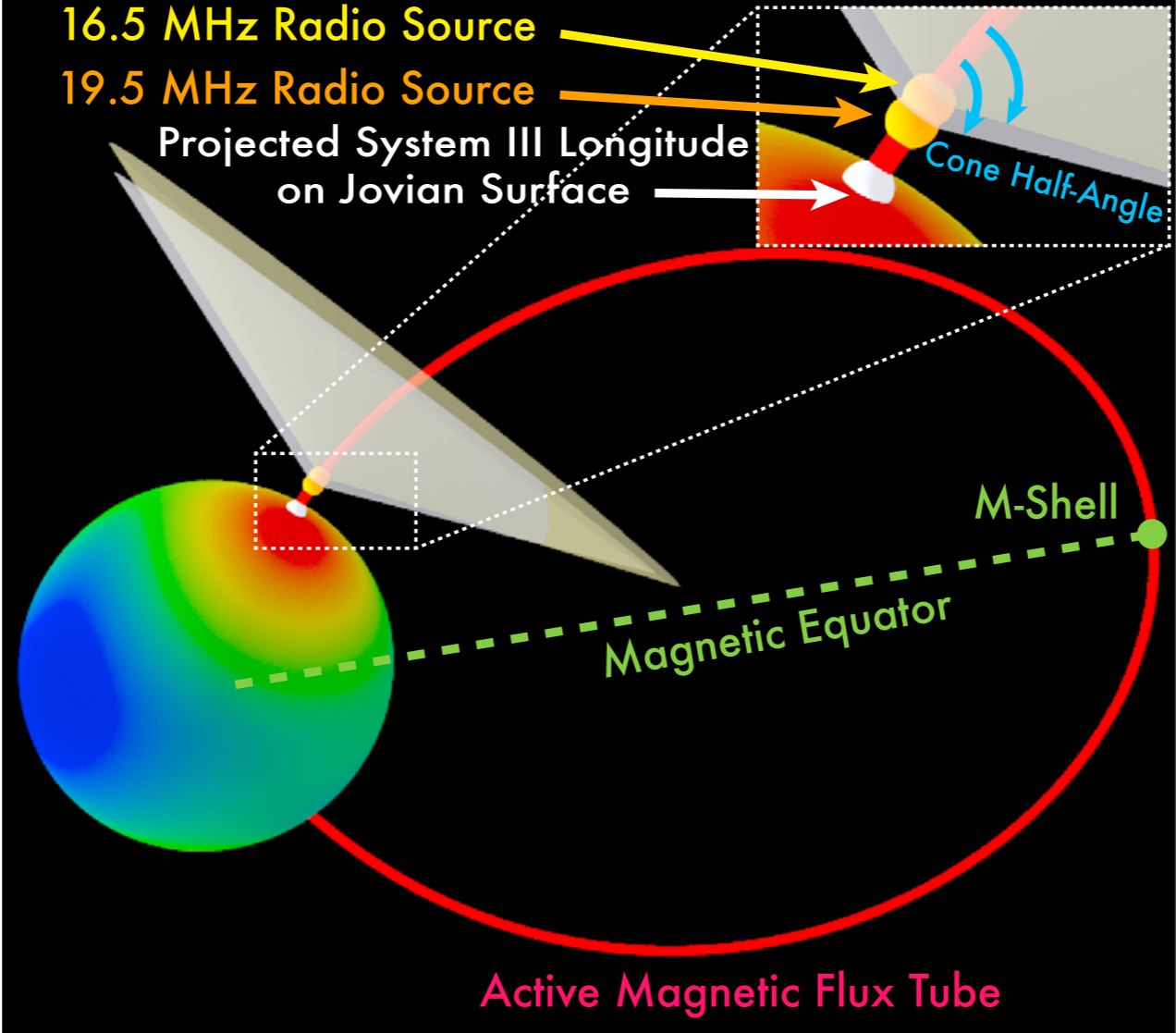
10.31°

West longitude ϕ_0

200.77°

196.61°

(a) Geometry of Jovian Radio Model



[Fig. 2 of Imai+, 2017b]

HDF5 original data and IDL reader

- The original hdf5 files and IDL reader for these files are available at <http://space.physics.uiowa.edu/juno/mwg/magfootprint.html> (Juno MWG website at UI).
- Currently, “Juno_Foot_PJXX_20190408_all.hdf5” (where XX=00 to 34) and “read_Juno_foot.pro” are being shared.
- Example of running “read_Juno_foot” procedure in IDL

```
Masafumi$ idl
IDL Version 8.3, Mac OS X (darwin x86_64 m64). (c) 2013, Exelis Visual Information Solutions, Inc.
Installation number: XXXXXX
Licensed for use by: University of Iowa

IDL> .rnew read_Juno_foot
% Compiled module: READ_JUNO_FOOT.
% Compiled module: TEST.
IDL> test
% Loaded DLM: HDF5.
JunoFoot_PJ18_20190408_all.hdf5    2458526.6    2458526.6    204.86850
  63.577764    37.429677    204.98638    63.622541    346.07294
  61.901187    359.47225    80.955793    253.71806    71.802482
  286.60351    84.370483    249.76165    75.540949    5.7137377
 -48.428061    16.556507   -61.233603    315.51533   -70.685424
  2.5346775   -68.740758    330.31321   -72.626584   1128041.3
  15.796060    0.0015930291  245.07433   -6.8770481    47.999395
-0.00030712749  204.98638    63.622541    15.796060   1128041.3
 272.07999   -79.709236    13.310347    4508123.1
```

- HDF5 files are supported in Autoplot, IDL, MATLAB, Python, C, Fortran, Java, C++, Mathematica.

Header of "read_Juno_foot.pro"

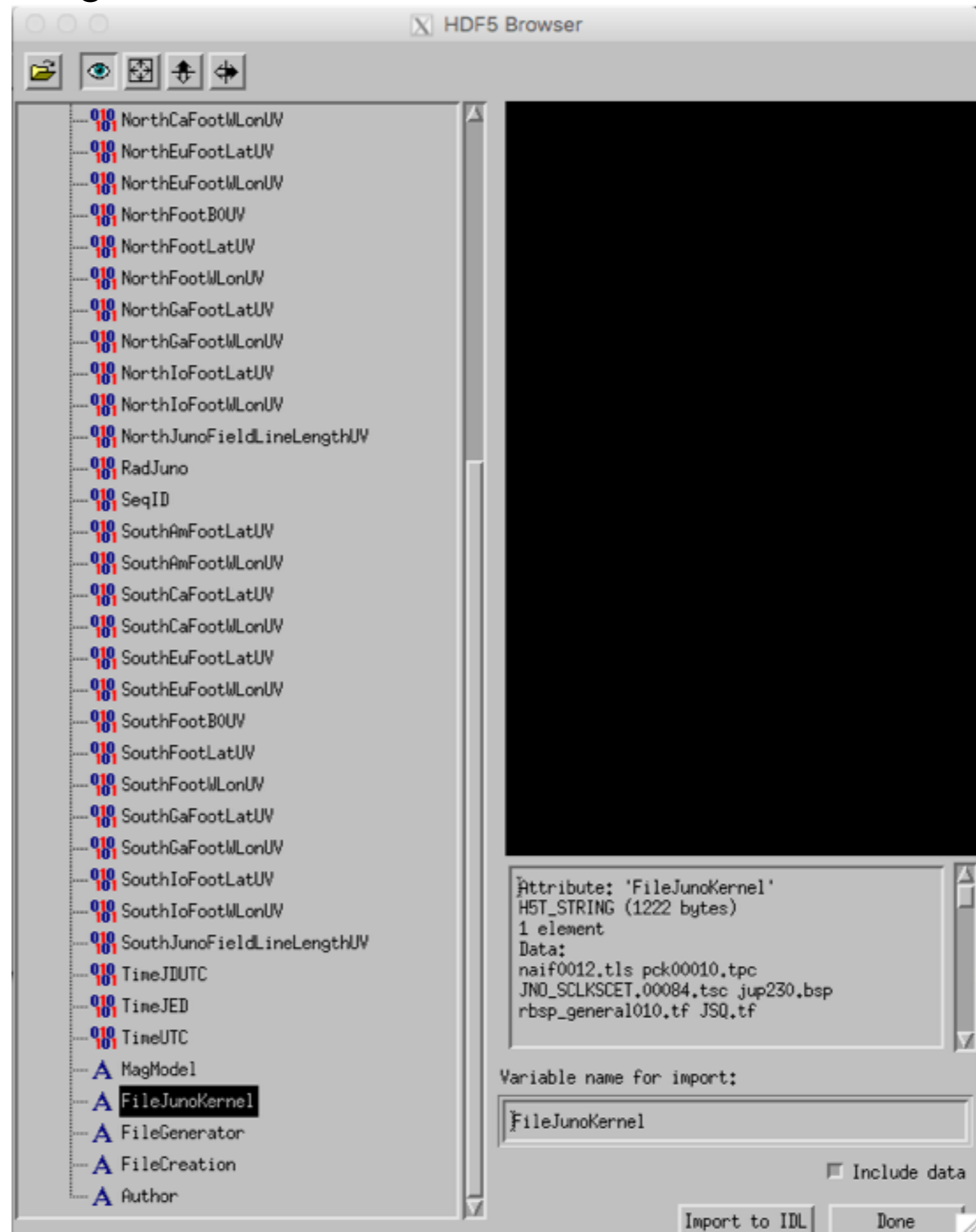
```
; all of computations were done with JRM09 + CS models
; file      <- File name
; jed       -> Julian ephemeris date (JED)
; jdutc     -> Julian Date UTC (jdutc)
; FootWlon  -> Juno footprint at 1-bar in System III W longitude
; FootLat   -> Juno footprint at 1-bar in Jovicentric latitude
; FootWlonUV -> Juno footprint at 400 km above 1-bar in System III W longitude
; FootLatUV -> Juno footprint at 400 km above 1-bar in Jovicentric latitude
; {North,South}FootWlon{Am,Io,Eu,Ga,Ca}UV
;           -> Footprints for {Amalthea, Io, Europa, Ganymede, Callisto} on
;           {northern, southern} hemisphere at 400 km above 1-bar in
;           System III W longitude
; {North,South}FootLat{Am,Io,Eu,Ga,Ca}UV
;           -> Footprints for {Amalthea, Io, Europa, Ganymede, Callisto} on
;           {northern, southern} hemisphere at 400 km above 1-bar in
;           Jovicentric latitude
; MShell    -> M-shell
; JunoFieldLineLengthUV -> Integrated length in km along Juno's magnetic field
;           line onto 400 km altitude above 1-bar level
; FootB0UV  -> Modeled magnetic field magnitude at Juno footprint, 400 km
;           above 1-bar
; JunoB0    -> Modeled magnetic field magnitude at the instantaneous Juno
;           position
; EqWLon    -> System III west longitude at the point crossing with the magnetic equator
; EqLat     -> Latitude at the point crossing with the magnetic equator
; MagEqWLon -> Magnetic longitude (based on JRM09 dipole) at the point crossing with the magnetic equator
; MagEqLat  -> Magnetic latitude (based on JRM09 dipole) at the point crossing with the magnetic equator
; {North,South}FootWlonUV -> Juno footprint on {northern, southern} hemisphere
;           at 400 km above 1-bar in System III W longitude
; {North,South}FootLatUV  -> Juno footprint on {northern, southern} hemisphere
;           at 400 km above 1-bar in Jovicentric latitude
; {North,South}FootB0UV   -> Modeled magnetic field magnitude on {northern, southern} hemisphere
;           at Juno footprint, 400 km above 1-bar
; {North,South}JunoFieldLineLengthUV -> Integrated length in km along Juno's magnetic field
;           line toward {northern, southern} hemisphere onto 400 km
;           altitude above 1-bar level
;
;
; N.B. -999.0 means undetermined data due to largest M-shell
; ---
; Author: Masafumi Imai (masafumi-imai@uiowa.edu)
;
```

Contents of HDF5 data (e.g. JunoFoot_PJ18_20190408_all.hdf5)

- Please note that the hdf5 files have more variables (including Juno kernel information) than those imported from my IDL reader.
- In accessing all variables, please type the following command in IDL.

```
IDL>  
h5=h5_browser('JunoFoot_PJ18_20190408_all.hdf5')  
% Compiled module: H5_BROWSER.  
% Compiled module: CW_TREESTRUCTURE.
```

- -999.0 means undetermined data due to largest M-shell.



The screenshot shows the HDF5 Browser window with a list of variables on the left and a details pane on the right. The variables list includes:

- NorthCaFootWLonUV
- NorthEuFootLatUV
- NorthEuFootWLonUV
- NorthFootB0UV
- NorthFootLatUV
- NorthFootWLonUV
- NorthGaFootLatUV
- NorthGaFootWLonUV
- NorthIoFootLatUV
- NorthIoFootWLonUV
- NorthJunoFieldLineLengthUV
- RadJuno
- SeqID
- SouthAmFootLatUV
- SouthAmFootWLonUV
- SouthCaFootLatUV
- SouthCaFootWLonUV
- SouthEuFootLatUV
- SouthEuFootWLonUV
- SouthFootB0UV
- SouthFootLatUV
- SouthFootWLonUV
- SouthGaFootLatUV
- SouthGaFootWLonUV
- SouthIoFootLatUV
- SouthIoFootWLonUV
- SouthJunoFieldLineLengthUV
- TimeJIUTC
- TimeJED
- TimeUTC
- MagModel
- FileJunoKernel**
- FileGenerator
- FileCreation
- Author

The details pane for 'FileJunoKernel' shows:

```
Attribute: 'FileJunoKernel'  
H5T_STRING (1222 bytes)  
1 element  
Data:  
naif0012.tls pck00010.tpc  
JNO_SCLKSCET.00084.tsc jup230.bsp  
rbsp_general010.tf JSQ.tf
```

Variable name for import:
FileJunoKernel

Include data

Import to IDL Done

Demonstration on JunoPigtailMoons.jy (1/2)

- Please download the recent Autoplot software (<http://autoplot.org>).
- <https://saturn.physics.uiowa.edu/svn/juno/public/jy/masafumi/JunoPigtailMoons.jy>

The image shows a screenshot of the Autoplot software interface. The main window displays a URL in the address bar: <https://saturn.physics.uiowa.edu/svn/juno/public/jy/masafumi/JunoPigtailMoons.jy>. An orange arrow points to this URL with the text "(1) Type Jython URL". To the right of the address bar, there is a folder icon, and an orange arrow points to it with the text "(2) Click 'Folder' symbol". Below the address bar, there are tabs for "curves", "axes", "style", "layout", "data", "metadata", "script", and "console". The main plot area is empty, with axes ranging from 0 to 100. In the bottom right corner, there is a "Run Script JunoPigtailMoons.jy" dialog box. An orange arrow points to the "params" tab in this dialog box with the text "(3) Then, select your options in 'params'". The dialog box contains the following parameters:

Parameter	Default Value
orbitNumber, the orbit number:	13
hemiSphere, the projected hemisphere:	North
specificTime, the specific time	F
Amalthea, Am Foot	F
Io, Io Foot	T
Europa, Eu Foot	F
Ganymede, Ga Foot	F
Callisto, Ca Foot	F

Buttons for "Cancel" and "Okay" are visible at the bottom of the dialog box.

Demonstration on JunoPigtailMoons.jy (2/2)

