EUROfusion TSVV-5
Python tool(s) for basic tally reading and line integral calculations

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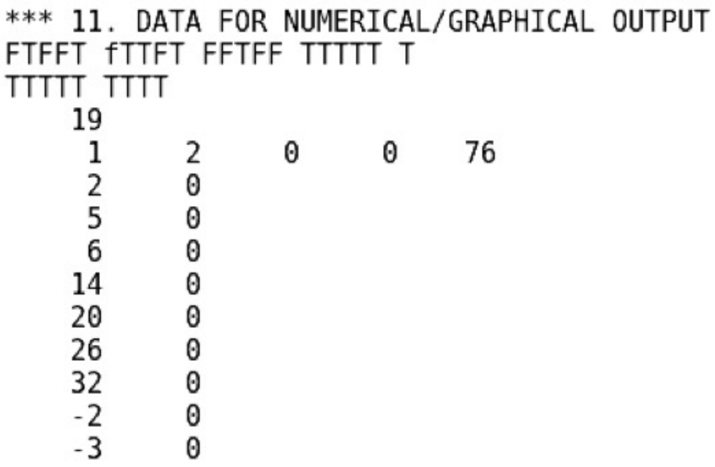
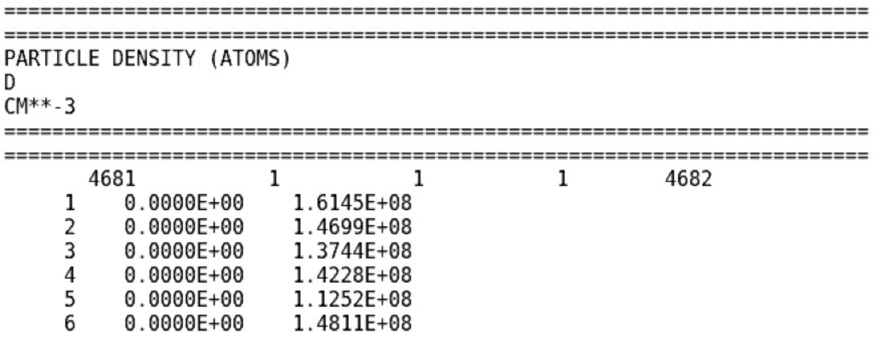
Motivation: standard/unified and (FZJ, TSVV-5) internal vetted Python tool to read out EIRENE tallies

- EIRENE internal graphical and numerical output of tallies controlled under block 11

⇒ Block 11A for numerical tallies, e.g., output of tally 1 (PDENA, see table 5.3 in EIRENE manual) in fort.76



```
*** 11. DATA FOR NUMERICAL/GRAPHICAL OUTPUT
FTFFT fTTFT FFTFF TTTTT T
TTTTT TTTT
    19
     1     2     0     0    76
     2     0
     5     0
     6     0
    14     0
    20     0
    26     0
    32     0
    -2     0
    -3     0
```



```
========================================================================
========================================================================
PARTICLE DENSITY (ATOMS)
D
CM**-3
========================================================================
========================================================================
       4681           1           1           1        4682
     1    0.0000E+00    1.6145E+08
     2    0.0000E+00    1.4699E+08
     3    0.0000E+00    1.3744E+08
     4    0.0000E+00    1.4228E+08
     5    0.0000E+00    1.1252E+08
     6    0.0000E+00    1.4811E+08
```

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- Setting PLIDL = T in block 11B prints output files for further processing in external tools (e.g. for FZJ IDL graphics tool)
  - **Grid** information as well as all **input** (plasma) and **output** tallies (excluding de-activated ones) are printed on files, one file per tally
  - Not all parameters are yet written out, e.g., both Lyman and Balmer emissivities as defined in block 12
  - JET EDGE2D-EIRENE cases: 10-15 MB

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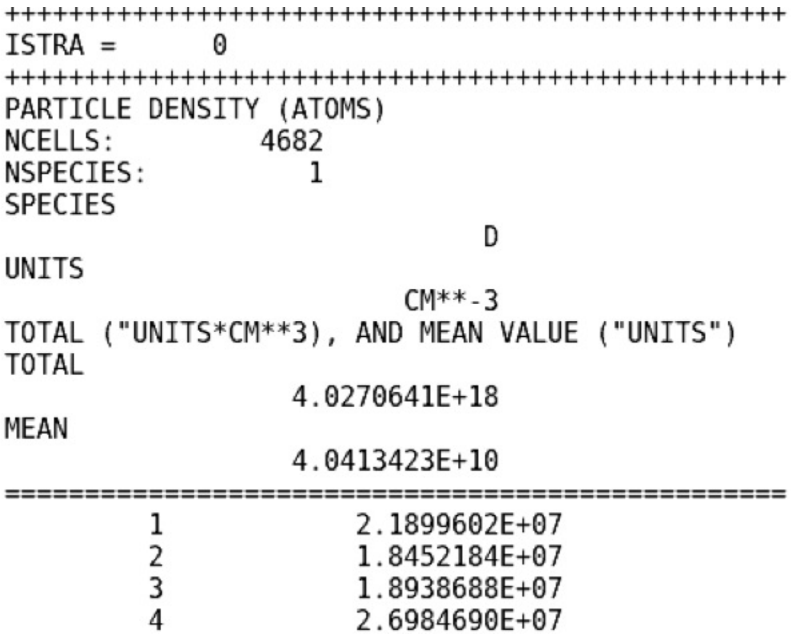
- More information in numerical output via PLIDL than when turning on tally output individually

⇒ Working with individually written tallies requires (small) modification of read routine



```
+++++++++++++++++++++++++++++++++++++++++++++++++
ISTRA =      0
+++++++++++++++++++++++++++++++++++++++++++++++++
PARTICLE DENSITY (ATOMS)
NCELLS:         4682
NSPECIES:          1
SPECIES
                              D
UNITS
                         CM**-3
TOTAL ("UNITS*CM**3), AND MEAN VALUE ("UNITS")
TOTAL
                  4.0270641E+18
MEAN
                  4.0413423E+10
=================================================
         1             2.1899602E+07
         2             1.8452184E+07
         3             1.8938688E+07
         4             2.6984690E+07
```

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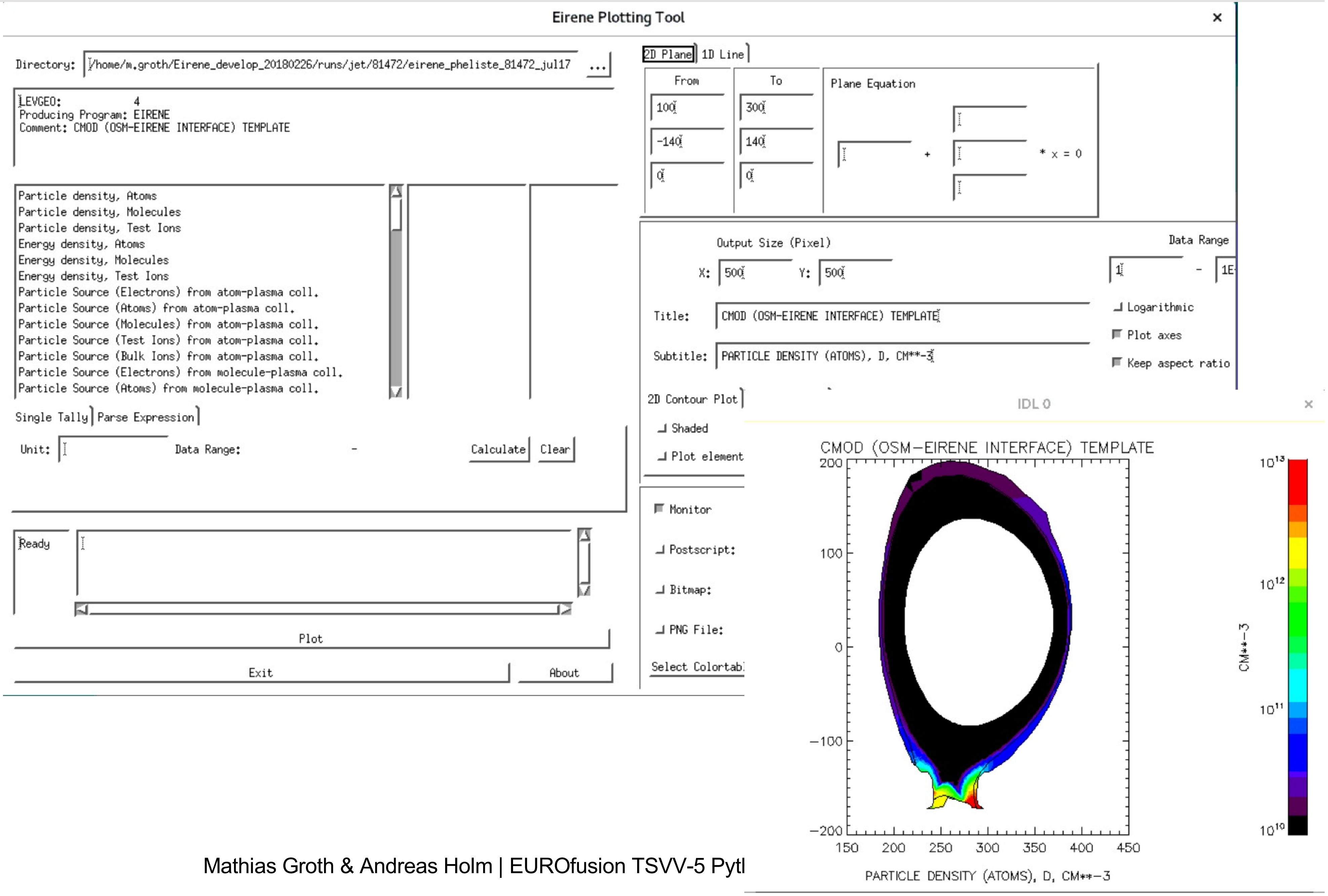
  - Volume tallies, post-processed line-integrals for ADDV

Flexible FZJ internal IDL tool to plot EIRENE tallies, requires IDL license (and FZJ permission)



Eirene Plotting Tool

Directory: /home/m.groth/Eirene_develop_20180226/runs/jet/81472/eirene_pheliste_81472_jul17

```
LEVGEO:              4
Producing Program: EIRENE
Comment: CMOD (OSM-EIRENE INTERFACE) TEMPLATE
```

```
Particle density, Atoms
Particle density, Molecules
Particle density, Test Ions
Energy density, Atoms
Energy density, Molecules
Energy density, Test Ions
Particle Source (Electrons) from atom-plasma coll.
Particle Source (Atoms) from atom-plasma coll.
Particle Source (Molecules) from atom-plasma coll.
Particle Source (Test Ions) from atom-plasma coll.
Particle Source (Bulk Ions) from atom-plasma coll.
Particle Source (Electrons) from molecule-plasma coll.
Particle Source (Atoms) from molecule-plasma coll.
```

Single Tally | Parse Expression

Unit: Data Range: -

Ready

2D Plane | 1D Line

From	To
100	300
-140	140
0	0

Plane Equation: + * x = 0

Output Size (Pixel) X: 500 Y: 500

Data Range: 1 - 1E

Title: CMOD (OSM-EIRENE INTERFACE) TEMPLATE

Subtitle: PARTICLE DENSITY (ATOMS), D, CM**-3

□ Logarithmic

☑ Plot axes

☑ Keep aspect ratio

2D Contour Plot

□ Shaded

□ Plot element

☑ Monitor

□ Postscript:

□ Bitmap:

□ PNG File:

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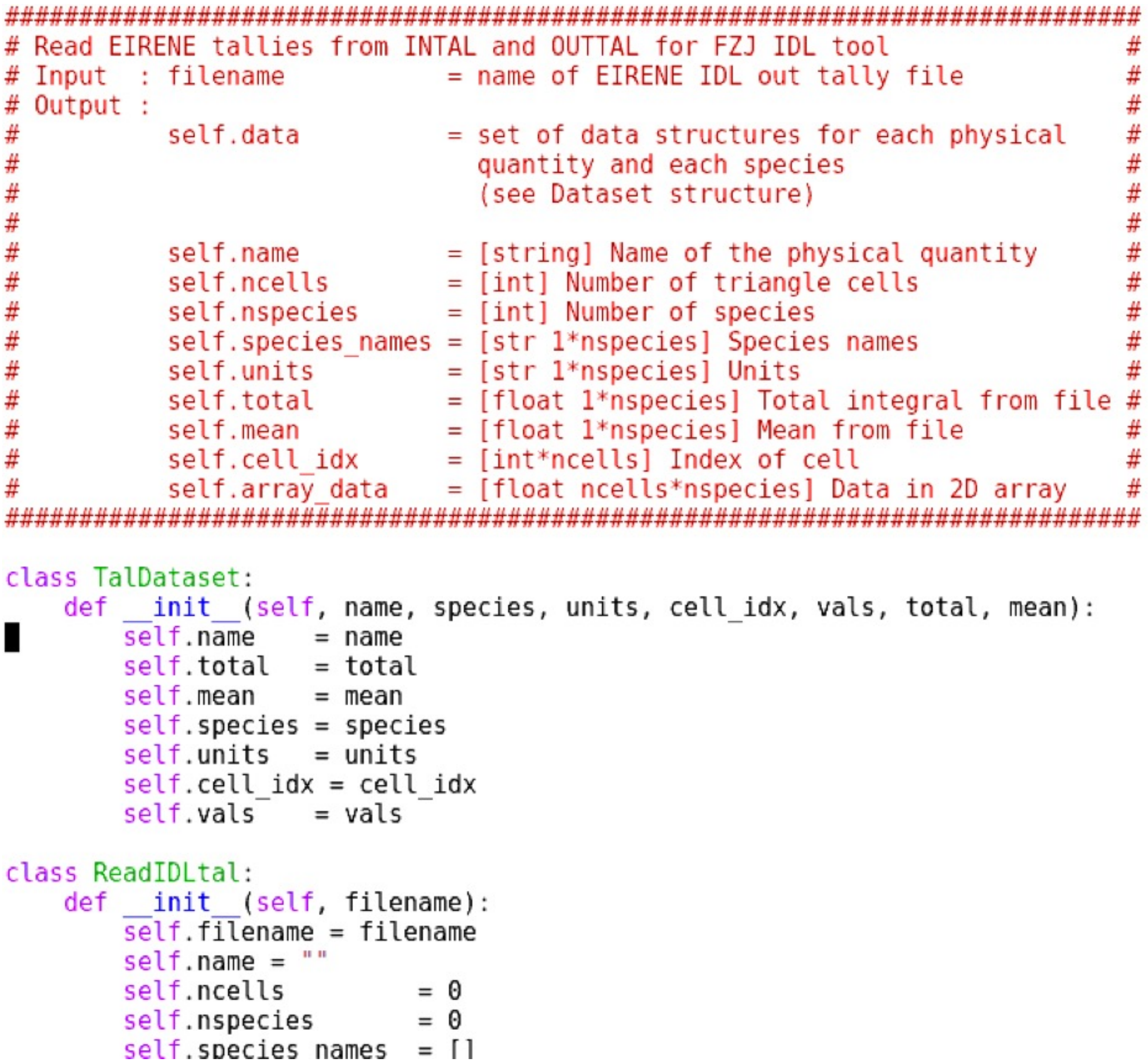
- FZJ-internal IDL tool to plot EIRENE “IDL” tallies, e.g., volume tallies, post-processed line-integrals

⇒ Plotting EIRENE output outside FZJ Linux cluster and further processing of EIRENE tallies requires platform less-dependent tool ⇒ **Python**

Built Python read routines (classes) around reading “IDL” tallies like FZJ IDL

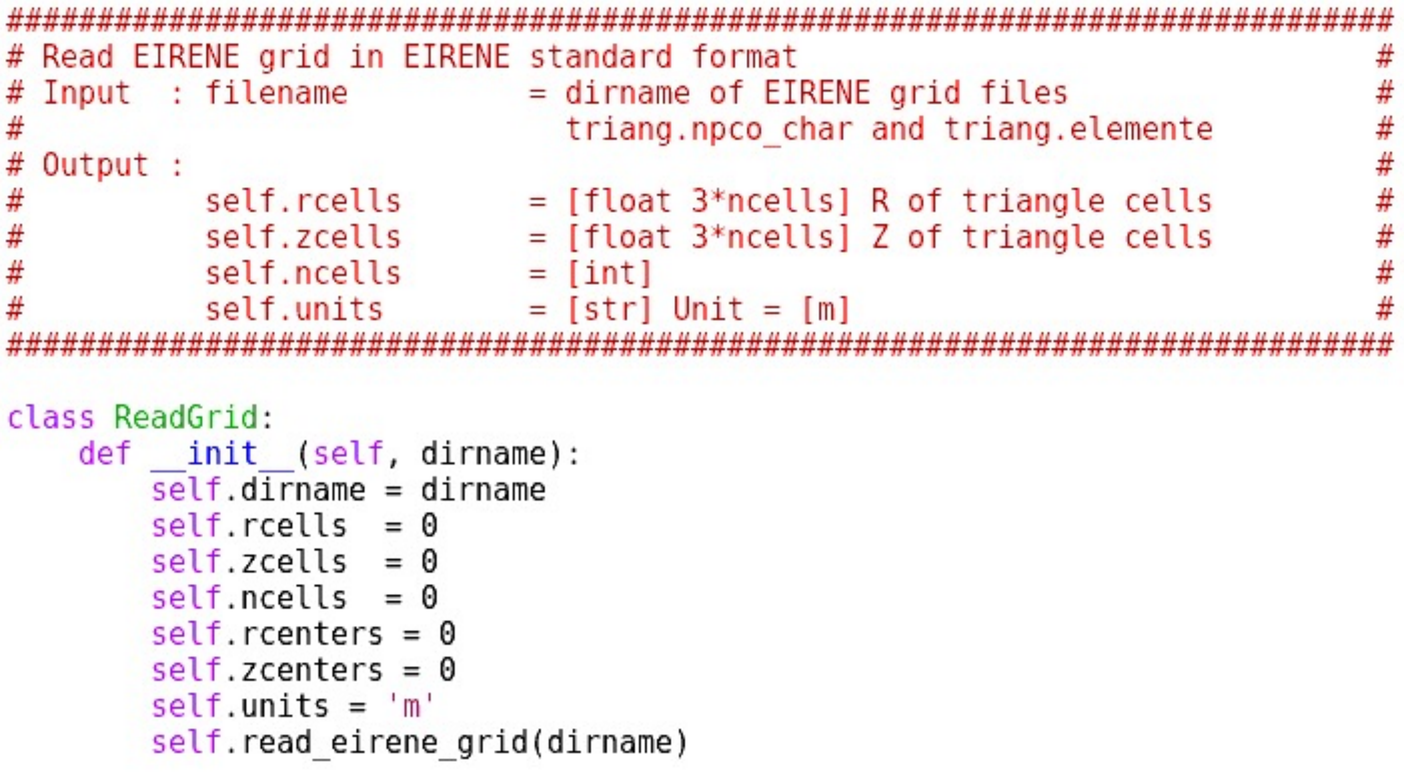


```
##############################################################################
# Read EIRENE tallies from INTAL and OUTTAL for FZJ IDL tool                 #
# Input   : filename          = name of EIRENE IDL out tally file            #
# Output :                                                                   #
#          self.data          = set of data structures for each physical     #
#                               quantity and each species                    #
#                               (see Dataset structure)                      #
#                                                                            #
#          self.name          = [string] Name of the physical quantity       #
#          self.ncells        = [int] Number of triangle cells               #
#          self.nspecies      = [int] Number of species                      #
#          self.species_names = [str 1*nspecies] Species names               #
#          self.units         = [str 1*nspecies] Units                       #
#          self.total         = [float 1*nspecies] Total integral from file  #
#          self.mean          = [float 1*nspecies] Mean from file            #
#          self.cell_idx      = [int*ncells] Index of cell                   #
#          self.array_data    = [float ncells*nspecies] Data in 2D array     #
##############################################################################

class TalDataset:
    def __init__(self, name, species, units, cell_idx, vals, total, mean):
        self.name    = name
        self.total   = total
        self.mean    = mean
        self.species = species
        self.units   = units
        self.cell_idx = cell_idx
        self.vals    = vals

class ReadIDLtal:
    def __init__(self, filename):
        self.filename = filename
        self.name = ""
        self.ncells         = 0
        self.nspecies       = 0
        self.species_names  = []
```

Grid files triang.npco_char and triang.elemente proved to be sufficient to plot grid



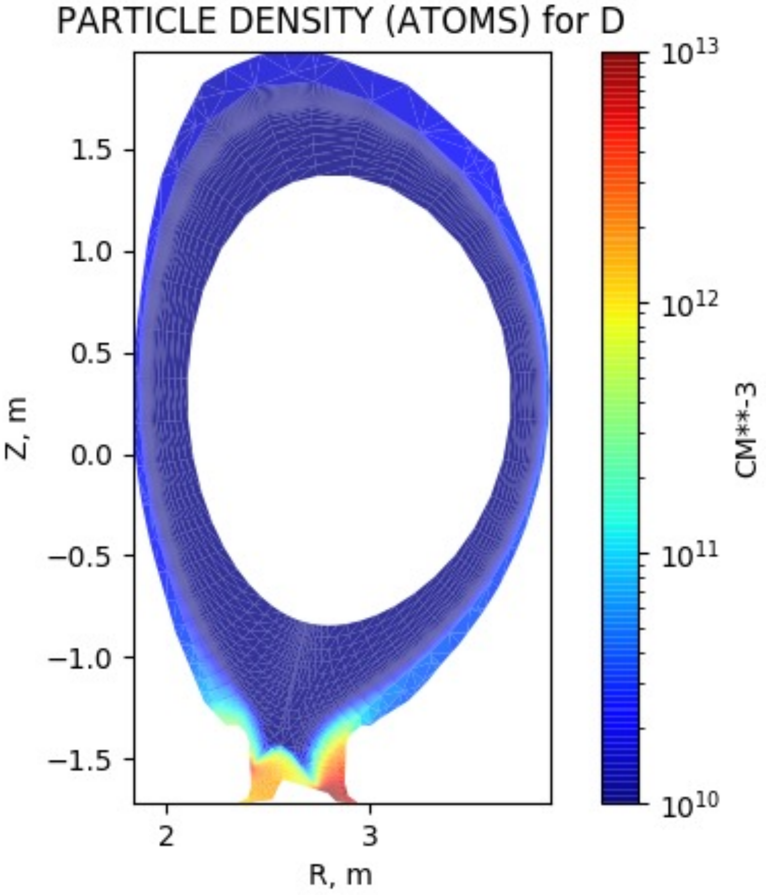
```
#############################################################################
# Read EIRENE grid in EIRENE standard format                                #
# Input   : filename          = dirname of EIRENE grid files                 #
#                               triang.npco_char and triang.elemente         #
# Output :                                                                  #
#          self.rcells        = [float 3*ncells] R of triangle cells         #
#          self.zcells        = [float 3*ncells] Z of triangle cells         #
#          self.ncells        = [int]                                        #
#          self.units         = [str] Unit = [m]                             #
#############################################################################

class ReadGrid:
    def __init__(self, dirname):
        self.dirname = dirname
        self.rcells  = 0
        self.zcells  = 0
        self.ncells  = 0
        self.rcenters = 0
        self.zcenters = 0
        self.units = 'm'
        self.read_eirene_grid(dirname)
```

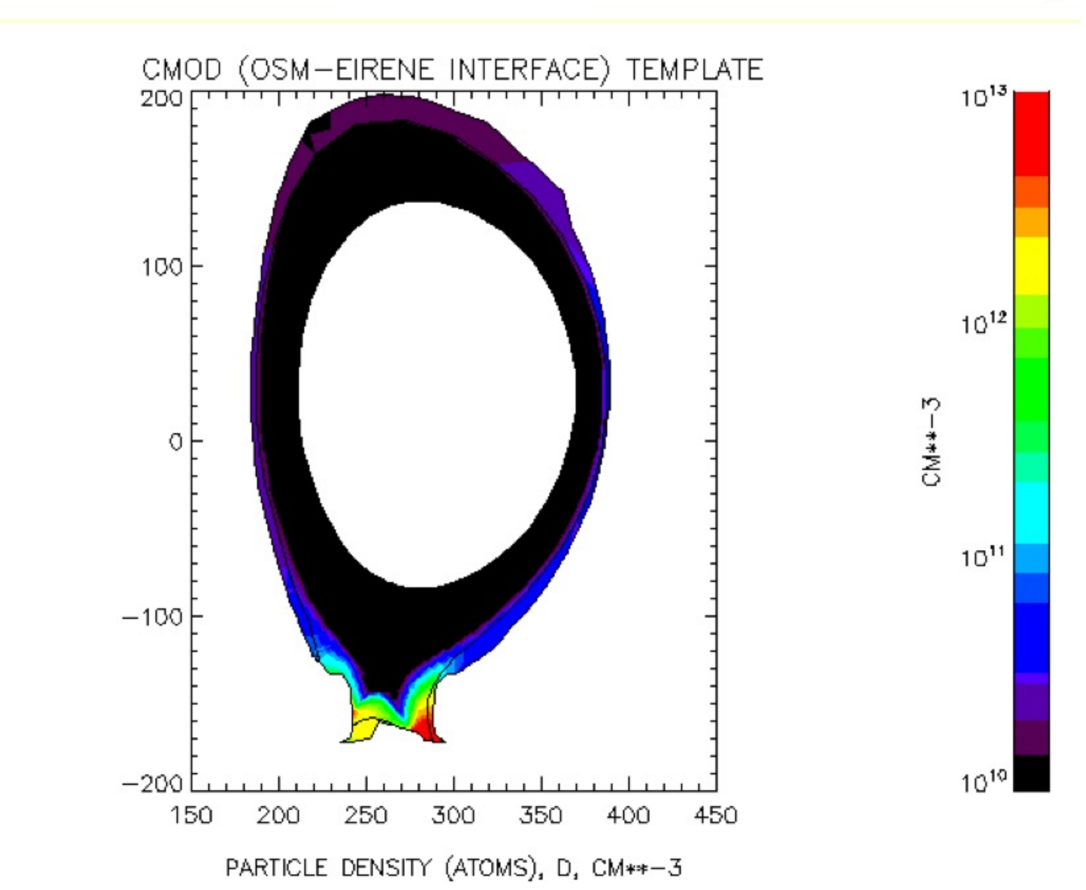
- Third grid output file for FZJ IDL tool, triang.neighbors, not yet used

Classes TalDataSet and ReadGrid + Python Matplotlib produce PDENA

Python



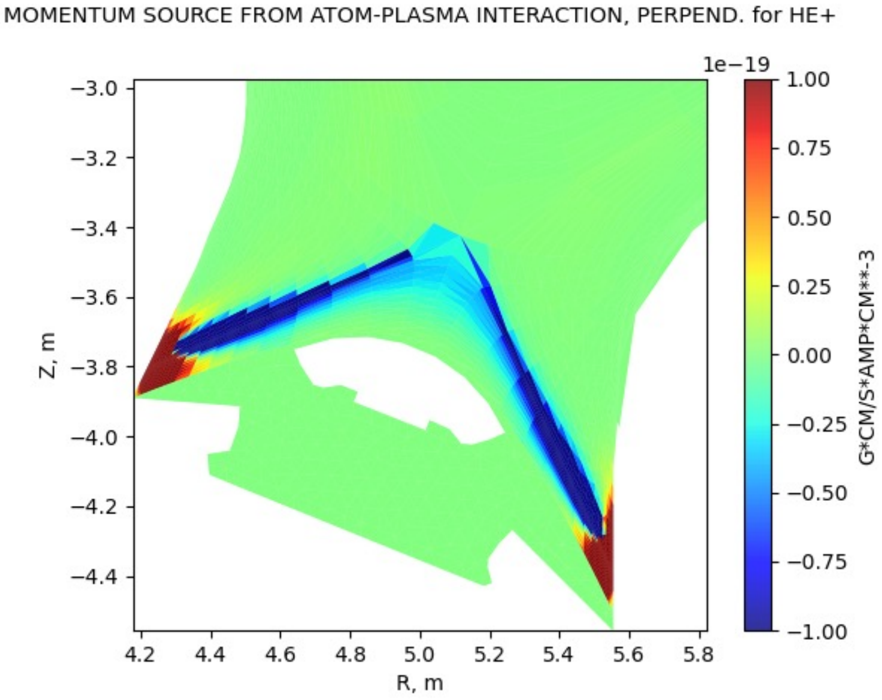
FZJ IDL



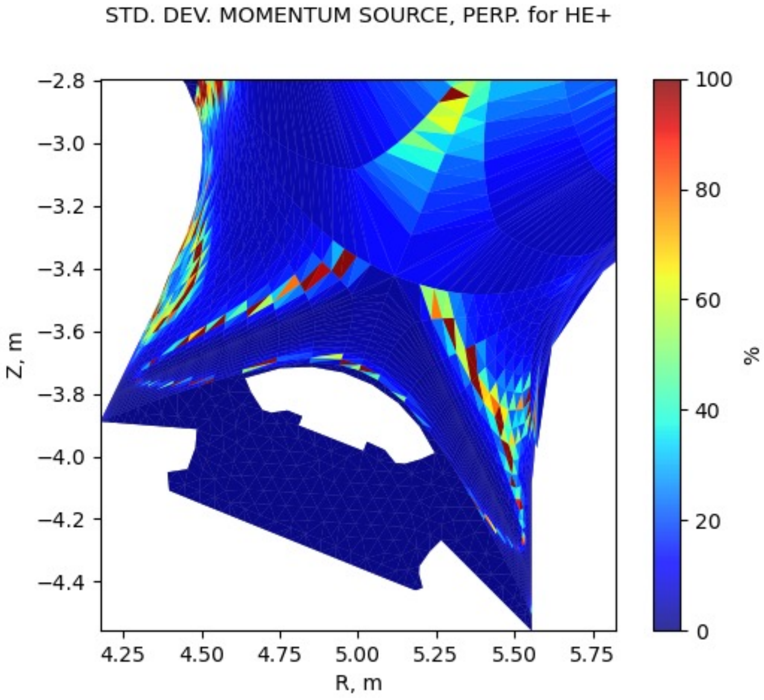
- Volume intal and outtal as in EIRENE manual tables 5.3 and 5.7 ⇒ differences in number of non-zero cells in tallies to be resolved

For NSIGVI ≠ 0 in block 9, variances of tally parameters are also produced

Mean value



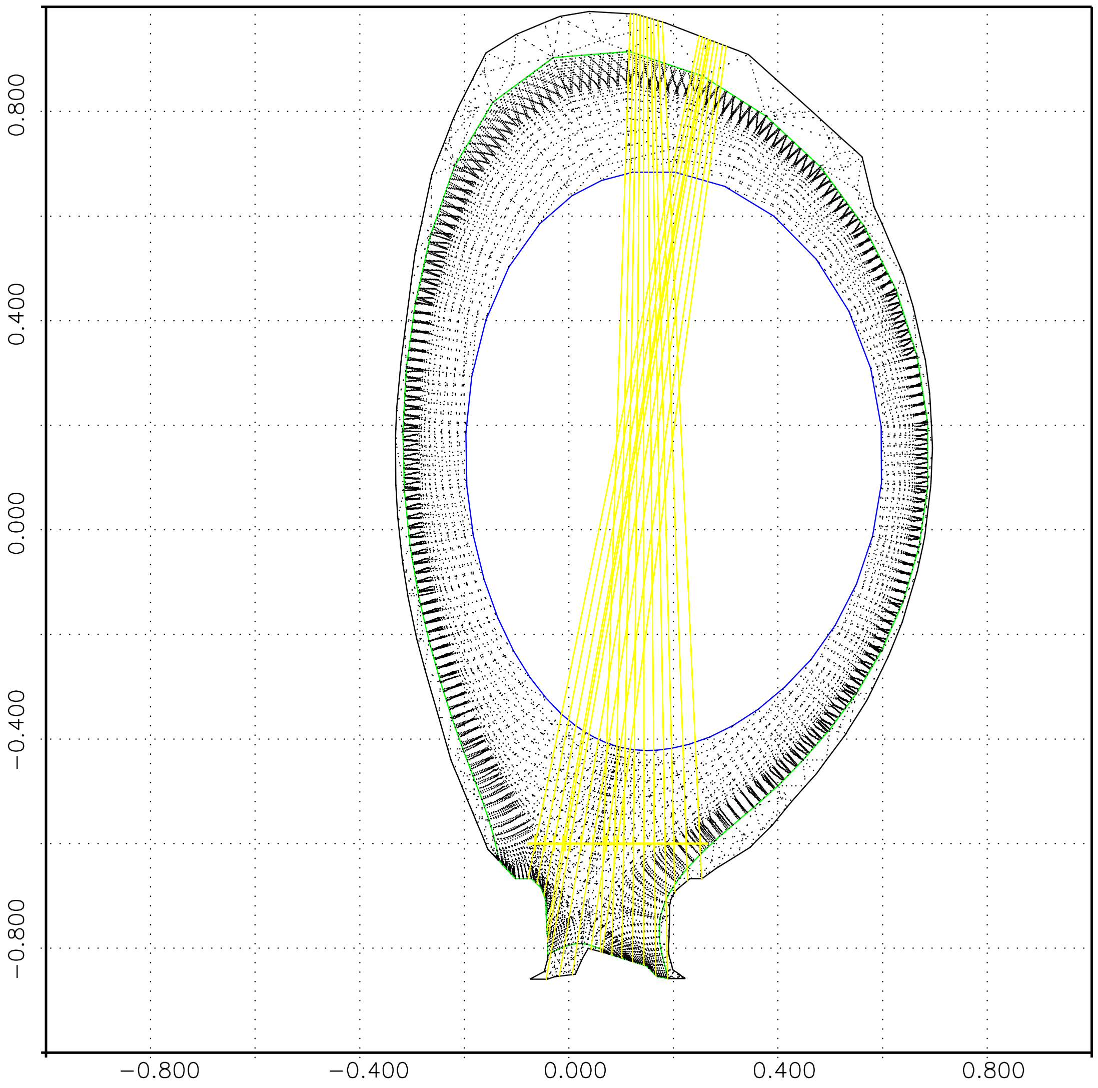
Standard deviation of mean value

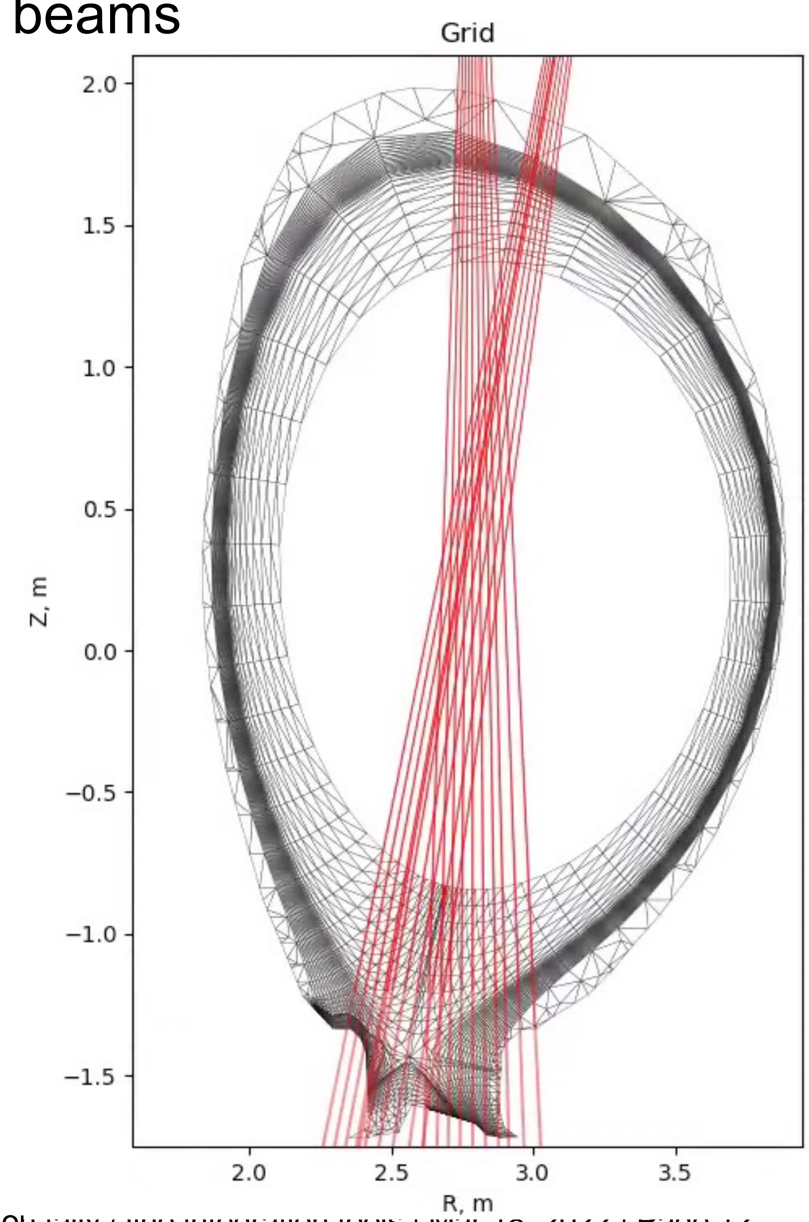


ISFN Feb 2022

Development of line-integration tools for comparison to spectroscopic measurements

EIRENE internal integration based on pencil beams





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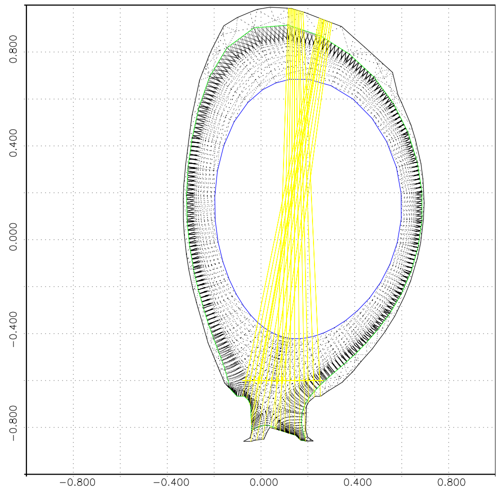
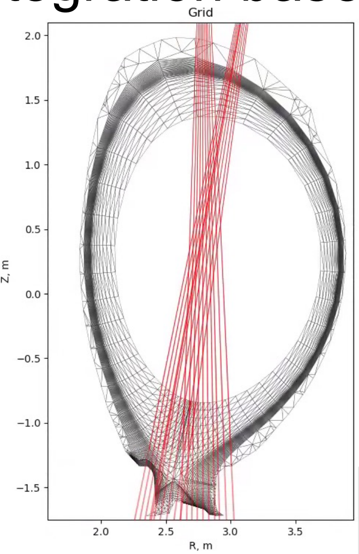
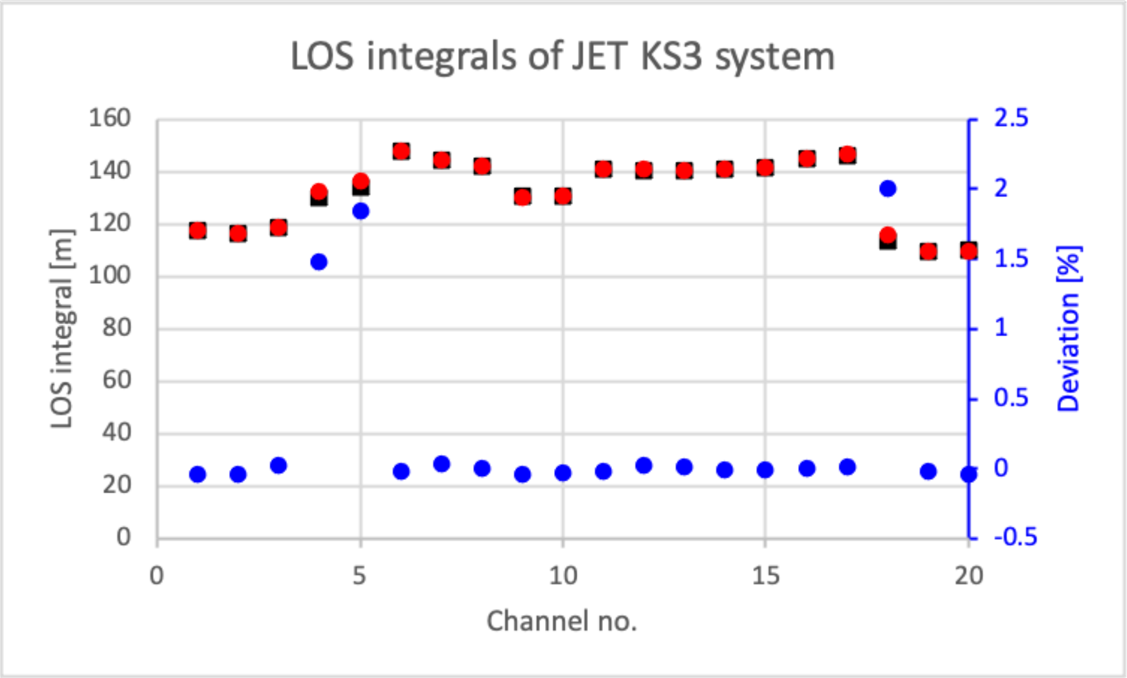
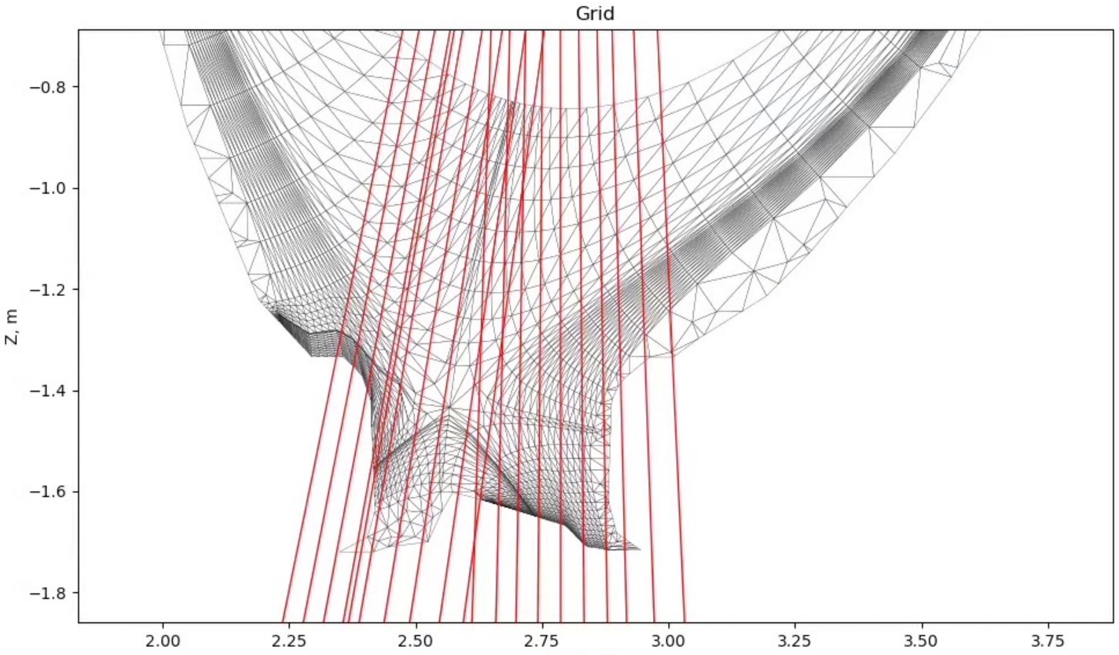


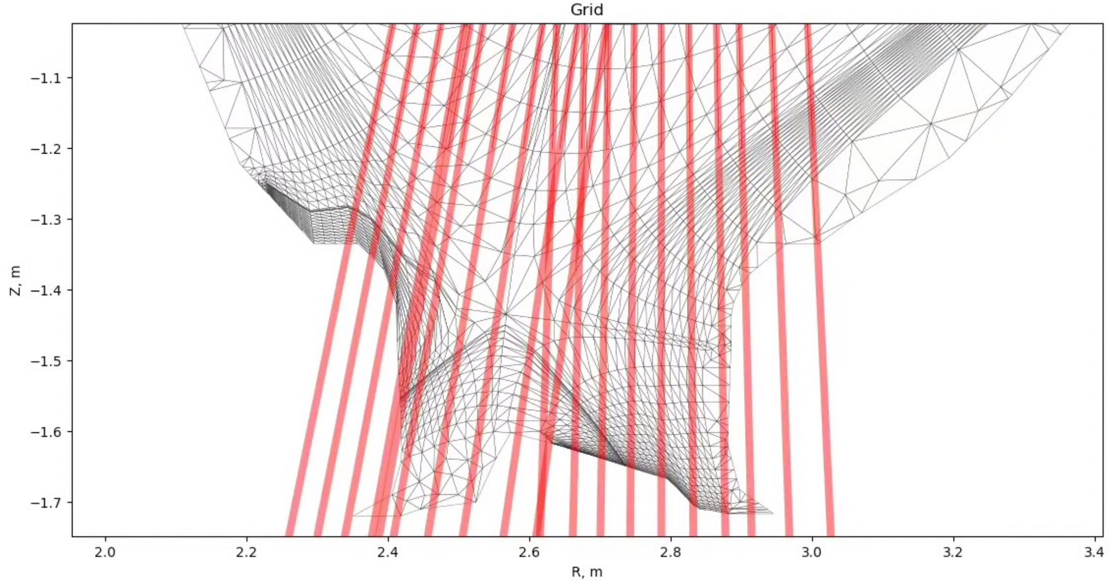




- Identified issue with LOS crossing EIRENE grid second time in divertor corner

Introduction of etendue in lines-of-sight for comparison to spectroscopic measurements





- Connection to SOLPSPY and Pyproc for SOLPS-ITER and EDGE2D-EIRENE

- Cherab (for reflections) ⇒ IMAS objects: LOS geometry definition, spectral lines, etc.

Additional ideas, issues on post-processing tool

- Routines run on FZJ, JET Heimdall and Aalto Triton Linux clusters
- Standalone EIRENE output based on converged EDGE2D-EIRENE cases
- Contour/vector plots for magnetic fields, particle (drift) velocities
- Variances of tally parameters
- Test grid and tally formats from other coupled codes, e.g., SOLPS-ITER, SOLEDEG2D-EIRENE, …
- Common plotting routines can be stored in Git repository in addition to basic routines (avoiding duplicate pain/work)

⇒ Other tally reading and plotting routines?

⇒ Place and maintenance of post-processing routines?

⇒ Fidelity check of post-processing routines, i.e., line integration tool?

Issues outside post-processing tools

- Modification to EIRENE Fortran routines ⇒ push to which Git repository?
    - Sven: angular resolved surface tallies
    - Mathias: line-integration tools in scr/diagno and src/user-routines/default-user
- Fidelity/consistency check and base-case testing of modified routines?