```
       )               (      (
  ( /(               )\ )   )\ )
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((_)\   )\    )\    /(_))  /(_))
  _((_) ((_)  ((_)  (_))   (_))
 | || | | __| | __| | _ \  / __|
 | __ | | _|  | _|  |  _/  \__ \
 |_||_| |___| |___| |_|    |___/
```
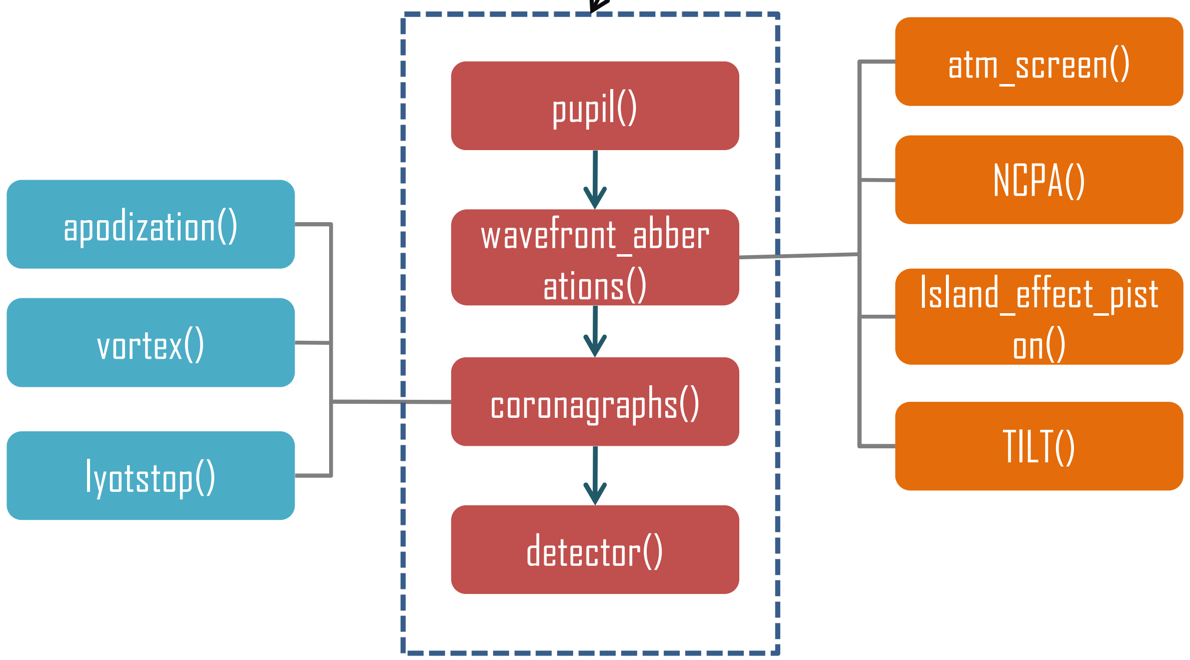
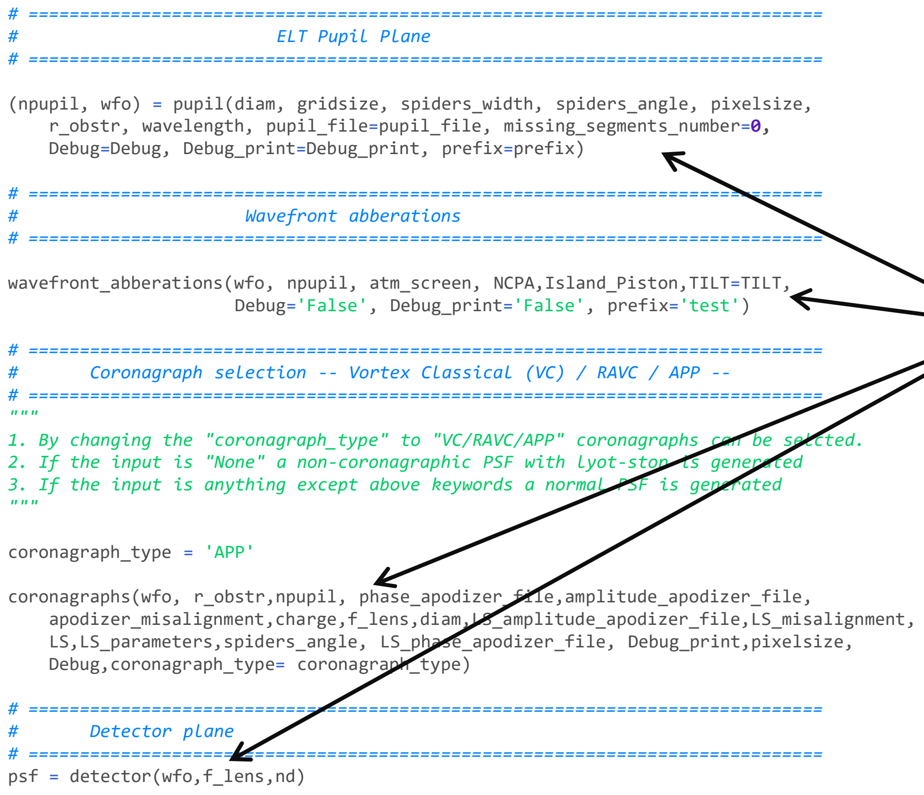

High-contrast End-to-end ELT Performance Simulator

HEEPS - Architecture

A normal or coronagraphic PSF can be generated using four main functions of HEEPS module, example code shown below

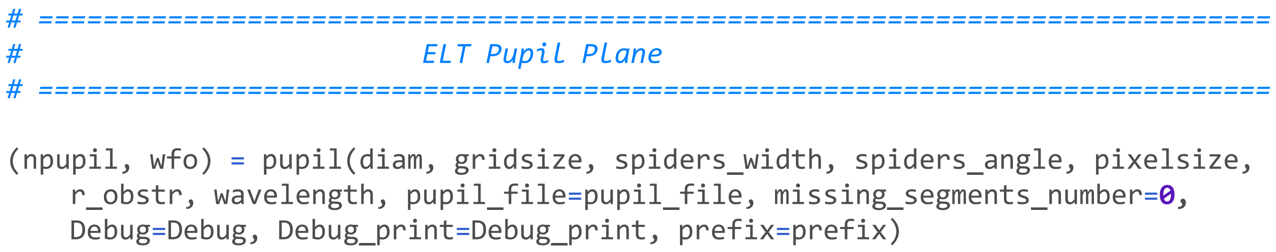




```
# ===========================================================================
#                          ELT Pupil Plane
# ===========================================================================

(npupil, wfo) = pupil(diam, gridsize, spiders_width, spiders_angle, pixelsize,
    r_obstr, wavelength, pupil_file=pupil_file, missing_segments_number=0,
    Debug=Debug, Debug_print=Debug_print, prefix=prefix)

# ===========================================================================
#                       Wavefront abberations
# ===========================================================================

wavefront_abberations(wfo, npupil, atm_screen, NCPA,Island_Piston,TILT=TILT,
                      Debug='False', Debug_print='False', prefix='test')

# ===========================================================================
#       Coronagraph selection -- Vortex Classical (VC) / RAVC / APP --
# ===========================================================================
"""
1. By changing the "coronagraph_type" to "VC/RAVC/APP" coronagraphs can be selcted.
2. If the input is "None" a non-coronagraphic PSF with lyot-stop is generated
3. If the input is anything except above keywords a normal PSF is generated
"""

coronagraph_type = 'APP'

coronagraphs(wfo, r_obstr,npupil, phase_apodizer_file,amplitude_apodizer_file,
    apodizer_misalignment,charge,f_lens,diam,LS_amplitude_apodizer_file,LS_misalignment,
    LS,LS_parameters,spiders_angle, LS_phase_apodizer_file, Debug_print,pixelsize,
    Debug,coronagraph_type= coronagraph_type)

# ===========================================================================
#       Detector plane
# ===========================================================================
psf = detector(wfo,f_lens,nd)
```

Four main functions

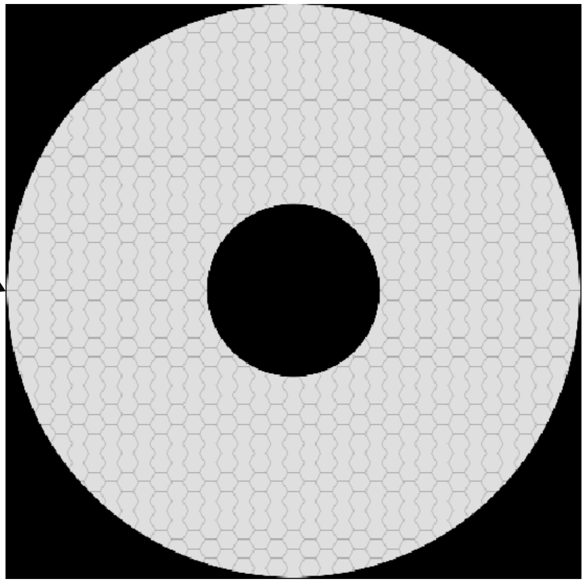
1. **pupil() -** architecture

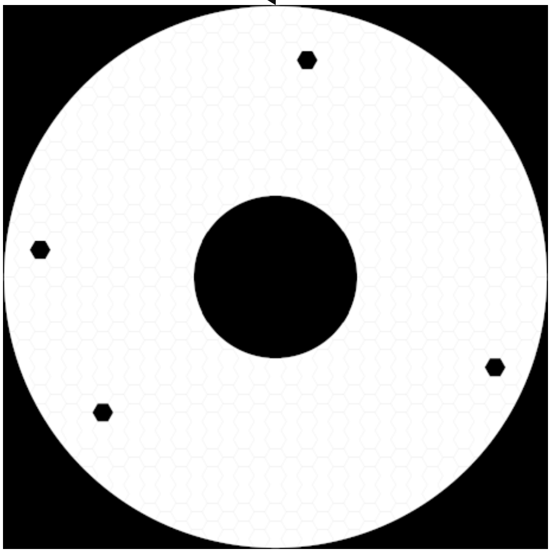


```
# ================================================================================
#                         ELT Pupil Plane
# ================================================================================

(npupil, wfo) = pupil(diam, gridsize, spiders_width, spiders_angle, pixelsize,
    r_obstr, wavelength, pupil_file=pupil_file, missing_segments_number=0,
    Debug=Debug, Debug_print=Debug_print, prefix=prefix)
```

Features:

- Input as fits file, SCAO team currently uses circular pupil with secondary obstruction, which is currently used and spiders are added to match with the internal mask.
- Choose from circ/spiders/obstruction.
- Missing segments can also be added.
- Island effects (not tested yet).





2. wavefront_abberations() - architecture

- Input phase screens from SCAO simulation (cube of 1000 phase screens)
- Effect of tip/tilt
- Island Piston
- Effect of NCPA's (static, DYNAMIC)

3. coronagraphs() - architecture

Types of coronagraphs include:

1. Vortex coronagraph (VC)
2. Ring apodized vortex coronagraph (RAVC)
3. Apodizing phase plate (APP)

(a) By changing the "coronagraph_type" to "VC/RAVC/APP" coronagraphs can be selcted.

(b) If the "coronagraph_type" is "None" a non-coronagraphic PSF with lyot-stop is generated.

(c) If the "coronagraph_type" is anything except above keywords a normal PSF is generated

▪Define LS parameters

▪LS stop misalignment can be defined

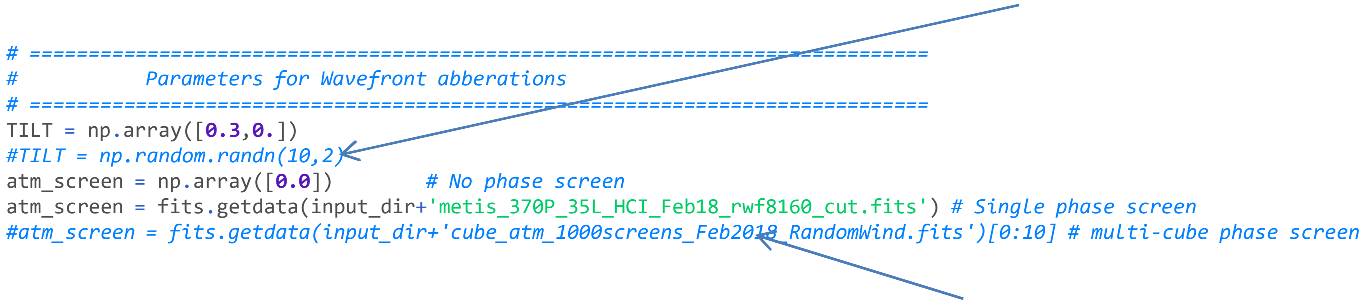
running example files:

There are two example files included with the HEEPS module:

1. *example_coronagraph_psf.py*: this example only generates single coronagraphic or non-coronagraphic PSF. The single parameter aberrations can be added here like; `TILT = np.array([0.3,0.])` # this will add a tilt of 0.3lambda/D.
   I will recommend familiarizing with the script by changing different parameters like; coronagraph_type, gridsize, wavelength etc.

1. *example_multi_cube_abberations.py*: this example generates a cube of PSF saved in the dir “output_files”. Please note: while applying tilt in conjugation with atm_screen, make sure the dimension are same.

will generate 10 random values of tilt



```
# =============================================================================
#           Parameters for Wavefront abberations
# =============================================================================
TILT = np.array([0.3,0.])
#TILT = np.random.randn(10,2)
atm_screen = np.array([0.0])        # No phase screen
atm_screen = fits.getdata(input_dir+'metis_370P_35L_HCI_Feb18_rwf8160_cut.fits') # Single phase screen
#atm_screen = fits.getdata(input_dir+'cube_atm_1000screens_Feb2018_RandomWind.fits')[0:10] # multi-cube phase screen
```

will select first 10 phase screens from a cube of 1000

Link to the cube 1000 phase screen:
https://drive.google.com/open?id=1AUtELRfn_xjnbsMM_SJG6W0c26zyzqNH