ECSN-Profile-Comparison

April 19, 2019

1 ECSN Profile Comparison

In [1]:
```
from StarKiller.initialization import starkiller_initialize
from StarKiller.interfaces import EosType
from StarKiller.interfaces import BurnType
from StarKiller.eos import Eos
from StarKiller.network import Network
from mesa_reader import MesaData
import numpy as np
import matplotlib.pyplot as plt
import matplotlib
```

1.1 Initialize Starkiller Microphysics

In [2]:
```
probin_file = "probin_ecsn"
```

In [3]:
```
starkiller_initialize(probin_file)
```

In [4]:
```
helmholtz = Eos()
ecsn = Network()
```

In [5]:
```
def evaluate_rhs(burn_state):
    ecsn.rhs(burn_state)
    return burn_state

def evaluate_eos(burn_state):
    eos_state = burn_state.to_eos_type()
    helmholtz.evaluate(eos_state.eos_input_rt, eos_state)
    return eos_state
```

1.2 Read MESA profile

In [6]:
```
mesa_data = MesaData("../../../../profiles/ONe6040-final.data")
```

In [7]:
```
mesa_enuc = mesa_data.eps_nuc_mc2 - mesa_data.eps_nuc_neu
```

In [8]:
```python
shared_species = []

for s in ecsn.short_species_names:
    if s in mesa_data.bulk_names:
        shared_species.append(s)

print("Species shared between MESA and Starkiller networks:\n")
for s in shared_species:
    print(s)
```

```
Species shared between MESA and Starkiller networks:

h1
he4
o16
o20
f20
ne20
mg24
si28
```

1.3 Evaluate the Starkiller equivalent of MESA (eps_nuc_mc2 - eps_nuc_neu)

In [9]:
```python
sk_burn_results = []
sk_eos_results = []

for zi in range(len(mesa_data.zone)):
    density = 10.0**mesa_data.logRho[zi]
    temperature = 10.0**mesa_data.logT[zi]

    # Set mass fractions for Starkiller network by zeroing
    # mass fractions for species missing in the MESA network and ignoring
    # species missing in the Starkiller network.
    #
    # Then renormalize the Starkiller mass fractions to sum to 1.
    mass_fractions = []

    for s in ecsn.short_species_names:
        if s in mesa_data.bulk_names:
            mass_fractions.append(mesa_data.data(s)[zi])
        else:
            mass_fractions.append(0.0)

    mass_fractions = np.array(mass_fractions)
    mass_fractions = mass_fractions/np.sum(mass_fractions)
```

```
    burn_state = BurnType()
    burn_state.state.rho = density
    burn_state.state.t = temperature
    burn_state.state.xn = mass_fractions

    # Evaluate the RHS and EOS in Starkiller
    sk_burn_results.append(evaluate_rhs(burn_state))
    sk_eos_results.append(evaluate_eos(burn_state))
```

```
In [10]: sk_eps = []

         for burn_state in sk_burn_results:
             sk_eps.append(burn_state.state.ydot[ecsn.net_ienuc])

         sk_eps = np.array(sk_eps)
```

1.4 Plot MESA and Starkiller energy generation rates

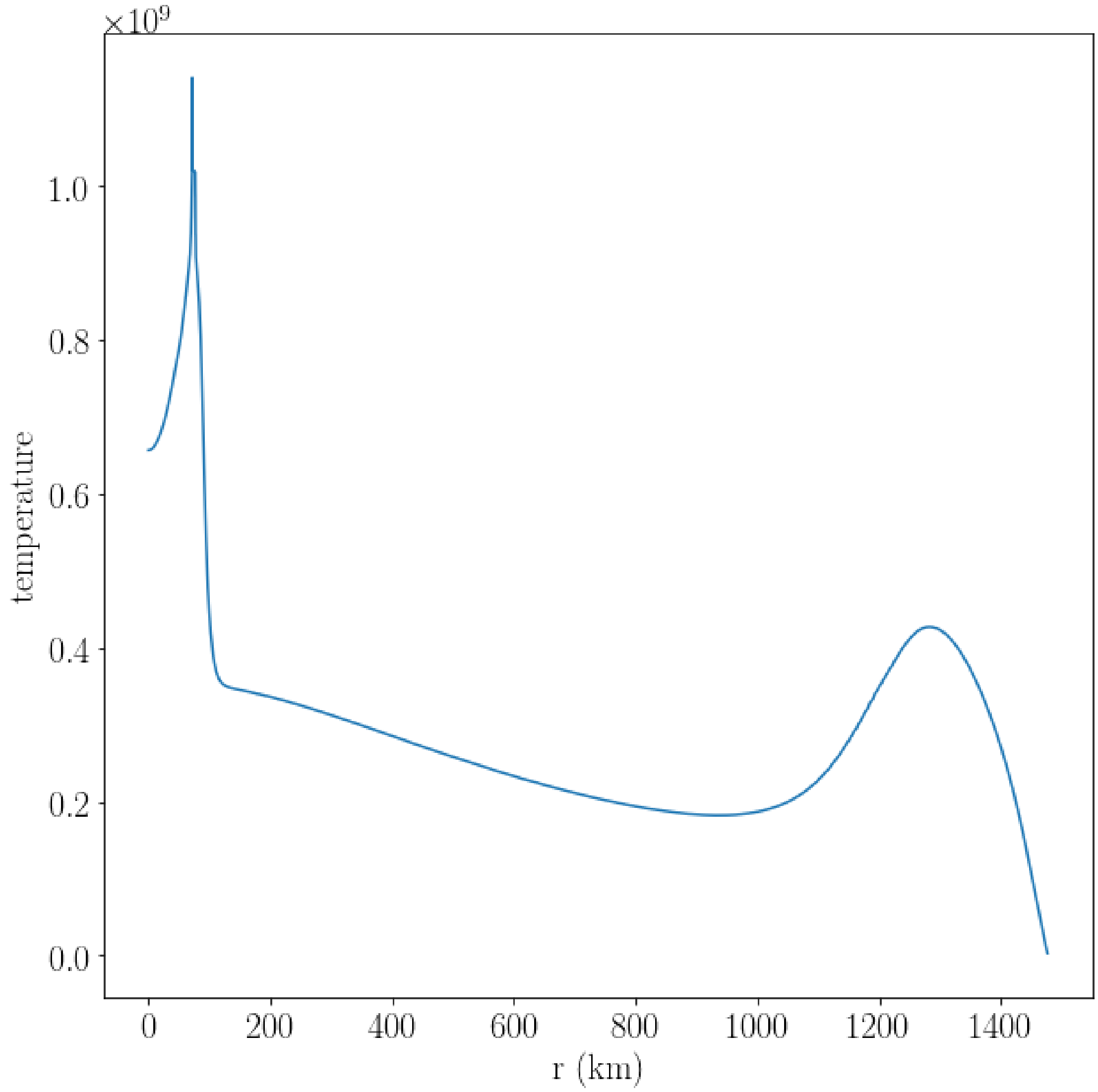
```
In [11]: font = {'size': 20}
         text = {'usetex': True}

         matplotlib.rc('font', **font)
         matplotlib.rc('text', **text)

         mesa_enuc_pos = np.maximum(mesa_enuc, 0.0)
         mesa_enuc_neg = np.maximum(-mesa_enuc, 0.0)

         sk_enuc_pos = np.maximum(sk_eps, 0.0)
         sk_enuc_neg = np.maximum(-sk_eps, 0.0)

         radius_km = mesa_data.radius_cm * 1.0e-5

         def plot_enuc(xlim=None, ylim=None):
             fig = plt.figure()
             fig.set_figheight(10.0)
             fig.set_figwidth(10.0)

             ax = fig.add_subplot(111)

             ax.plot(radius_km, mesa_enuc_pos, color='b', linestyle='-',
                     label=r'$\mathrm{MESA}$ $\dot{\varepsilon} > 0$')

             ax.plot(radius_km, mesa_enuc_neg, color='b', linestyle=':',
                     label=r'$\mathrm{MESA}$ $\dot{\varepsilon} < 0$')

             ax.plot(radius_km, sk_enuc_pos, color='g', linestyle='-',
                     label=r'$\mathrm{StarKiller}$ $\dot{\varepsilon} > 0$')
```

```
        ax.plot(radius_km, sk_enuc_neg, color='g', linestyle=':',
                label=r'$\mathrm{StarKiller}$ $\dot{\varepsilon} < 0$')

        ax.set_yscale('log')

        if xlim:
            ax.set_xlim(xlim)

        if ylim:
            ax.set_ylim(ylim)

        ax.set_xlabel(r'$\mathrm{r\ (km)}$')
        ax.set_ylabel(r'$\dot{\varepsilon} = \dot{\varepsilon}_{m c^2} - |\dot{\varepsilon}
        ax.legend(loc='upper right')

        plt.show()
```

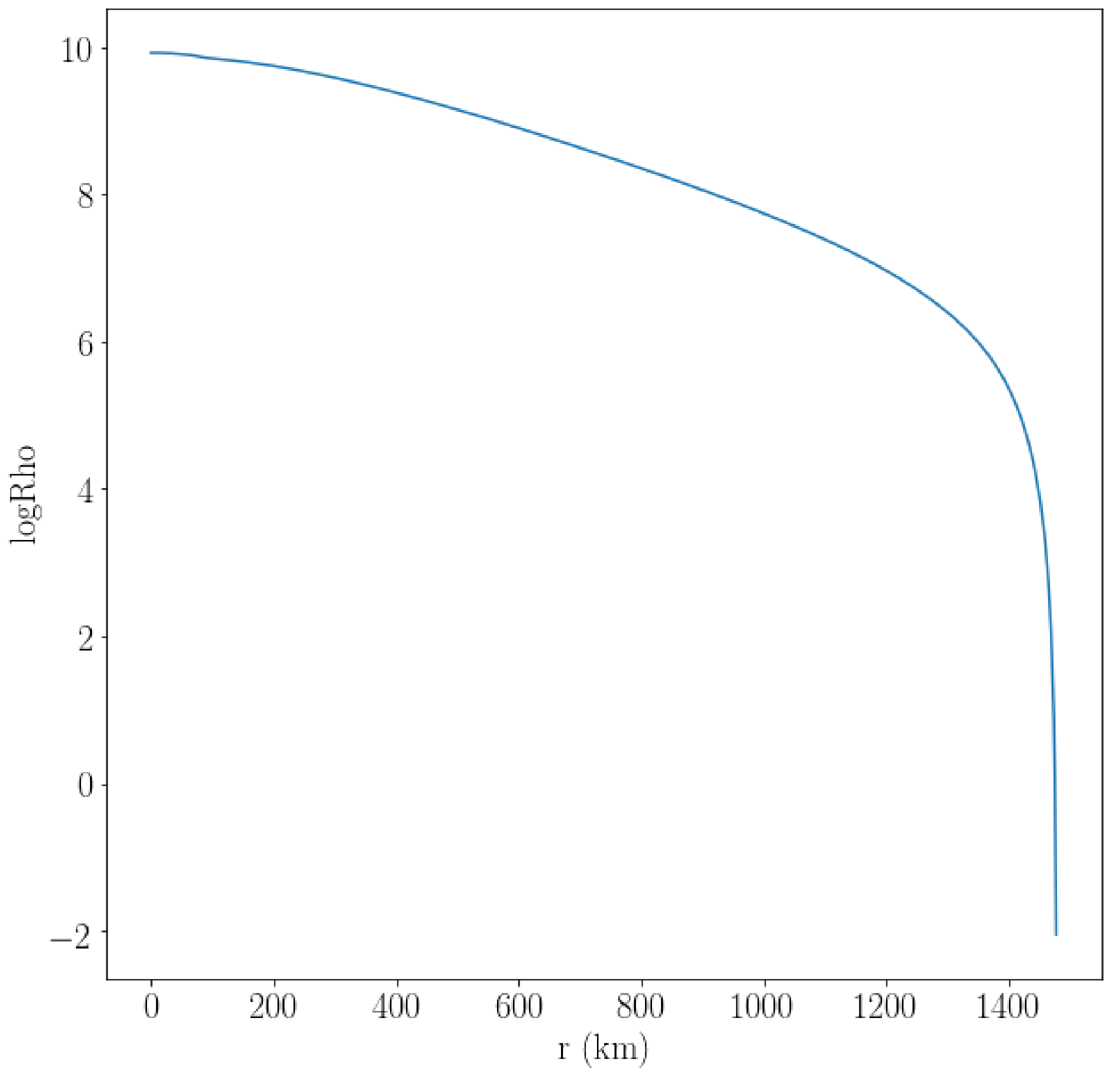
```
In [12]: def plot_field(xlim=None, ylim=None, mesa_field="temperature"):
             fig = plt.figure()
             fig.set_figheight(10.0)
             fig.set_figwidth(10.0)

             ax = fig.add_subplot(111)

             ax.plot(radius_km, mesa_data.data(mesa_field))

             if xlim:
                 ax.set_xlim(xlim)

             if ylim:
                 ax.set_ylim(ylim)

             ax.set_xlabel(r'$\mathrm{r\ (km)}$')
             ax.set_ylabel(r'$\mathrm{' + '{}'.format(mesa_field) + r'}$')

             plt.show()
```

1.4.1 Entire Profile

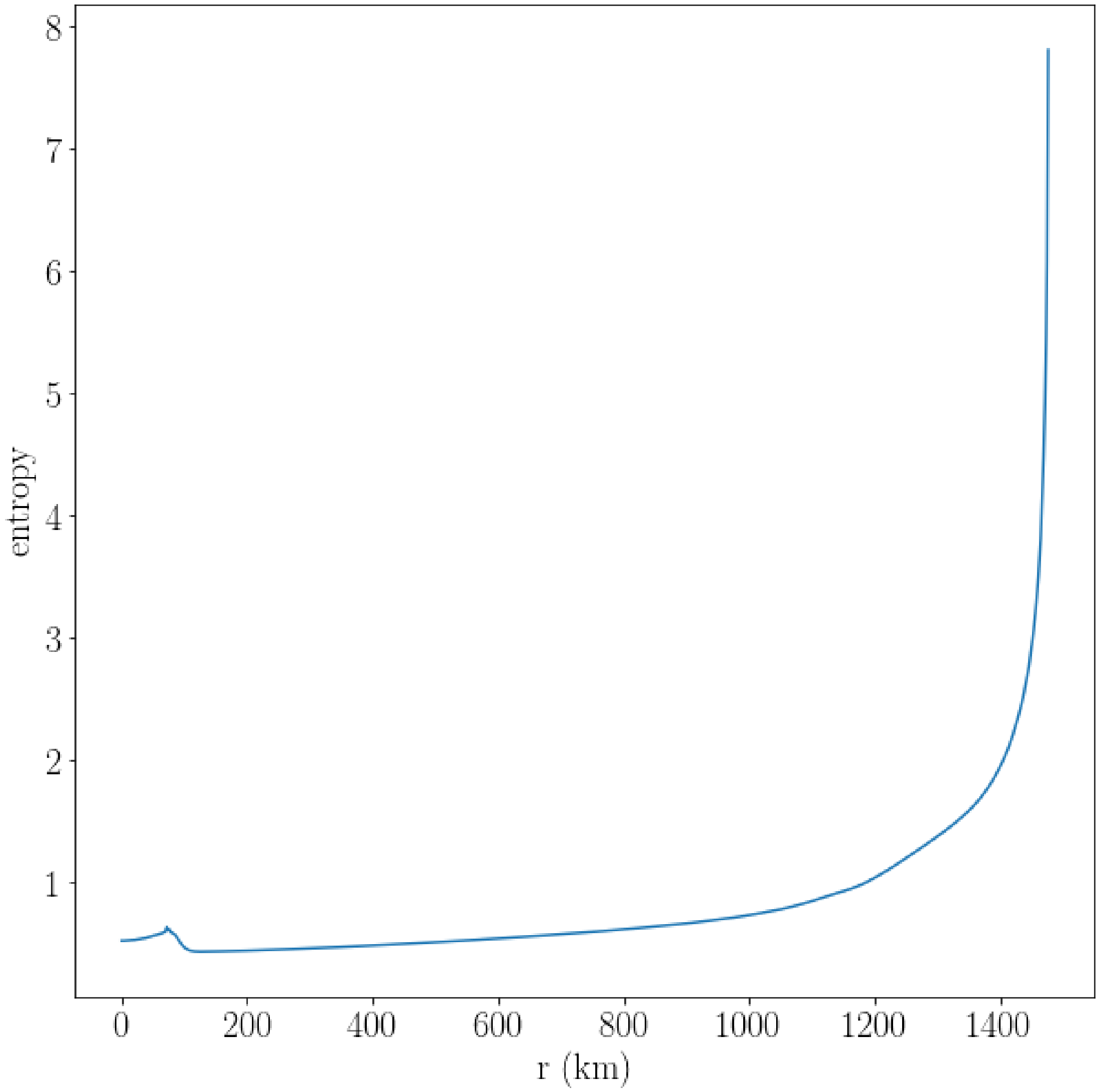
```
In [13]: plot_field(mesa_field='temperature')
```



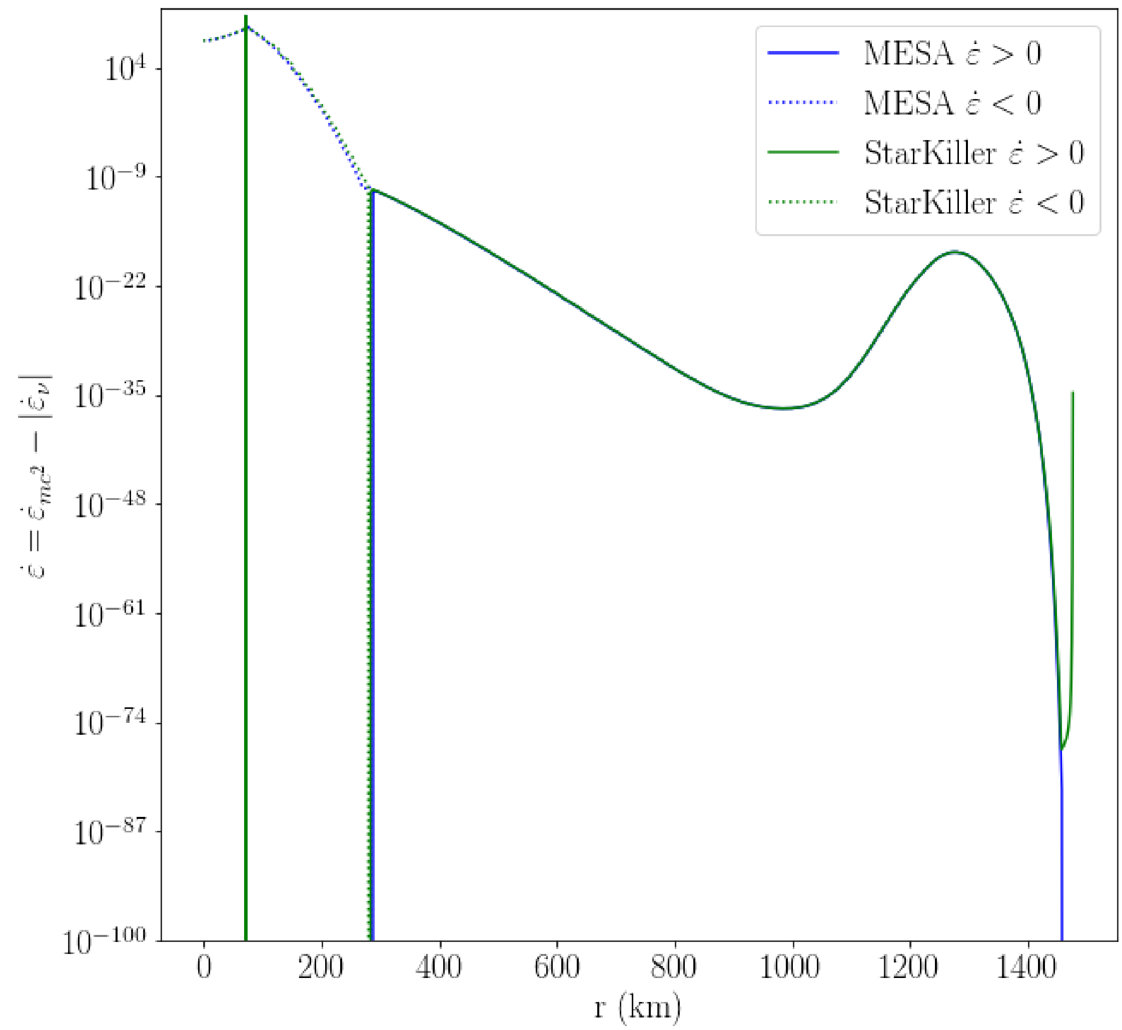

```
In [14]: plot_field(mesa_field='logRho')
```




```
In [15]: plot_field(mesa_field='entropy')
```

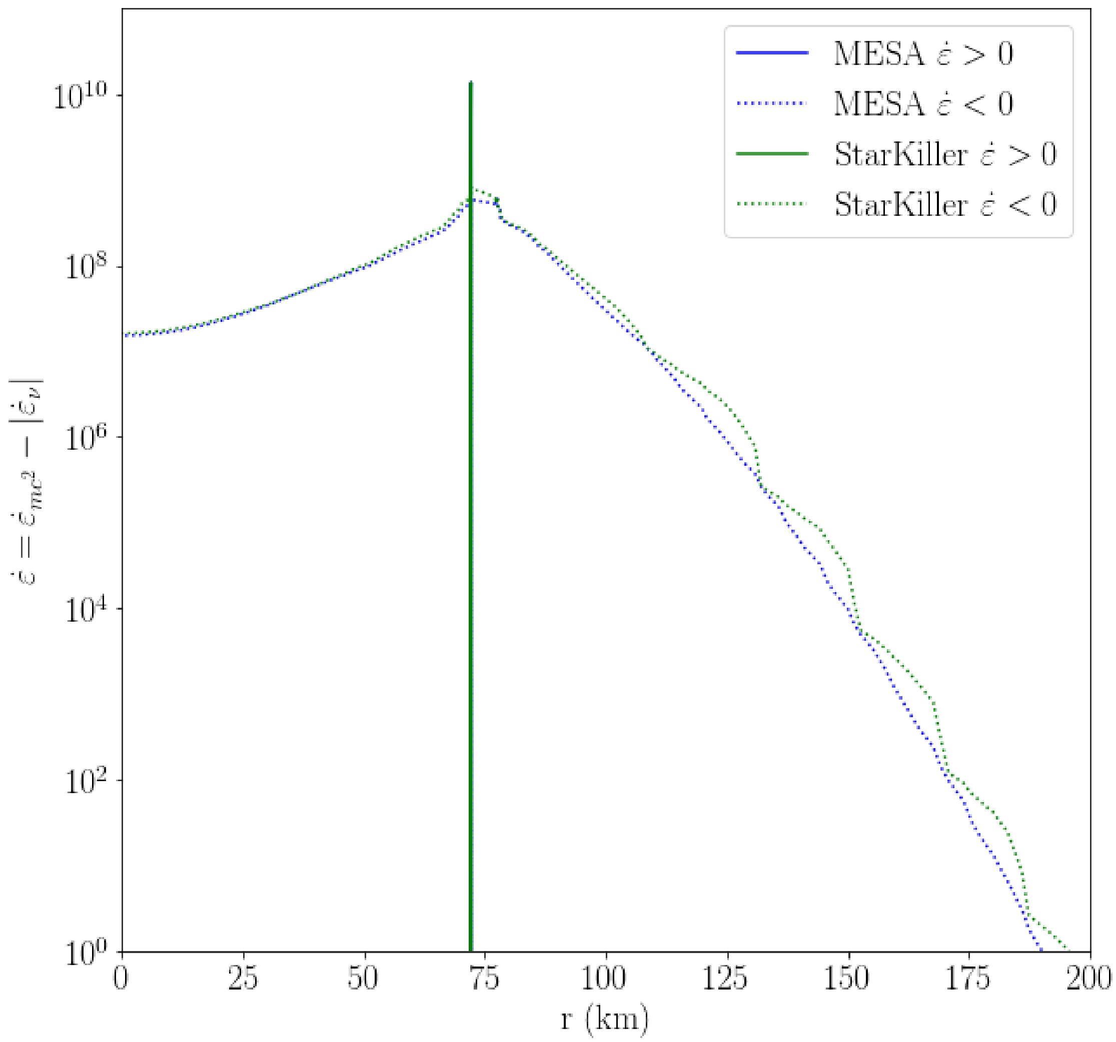


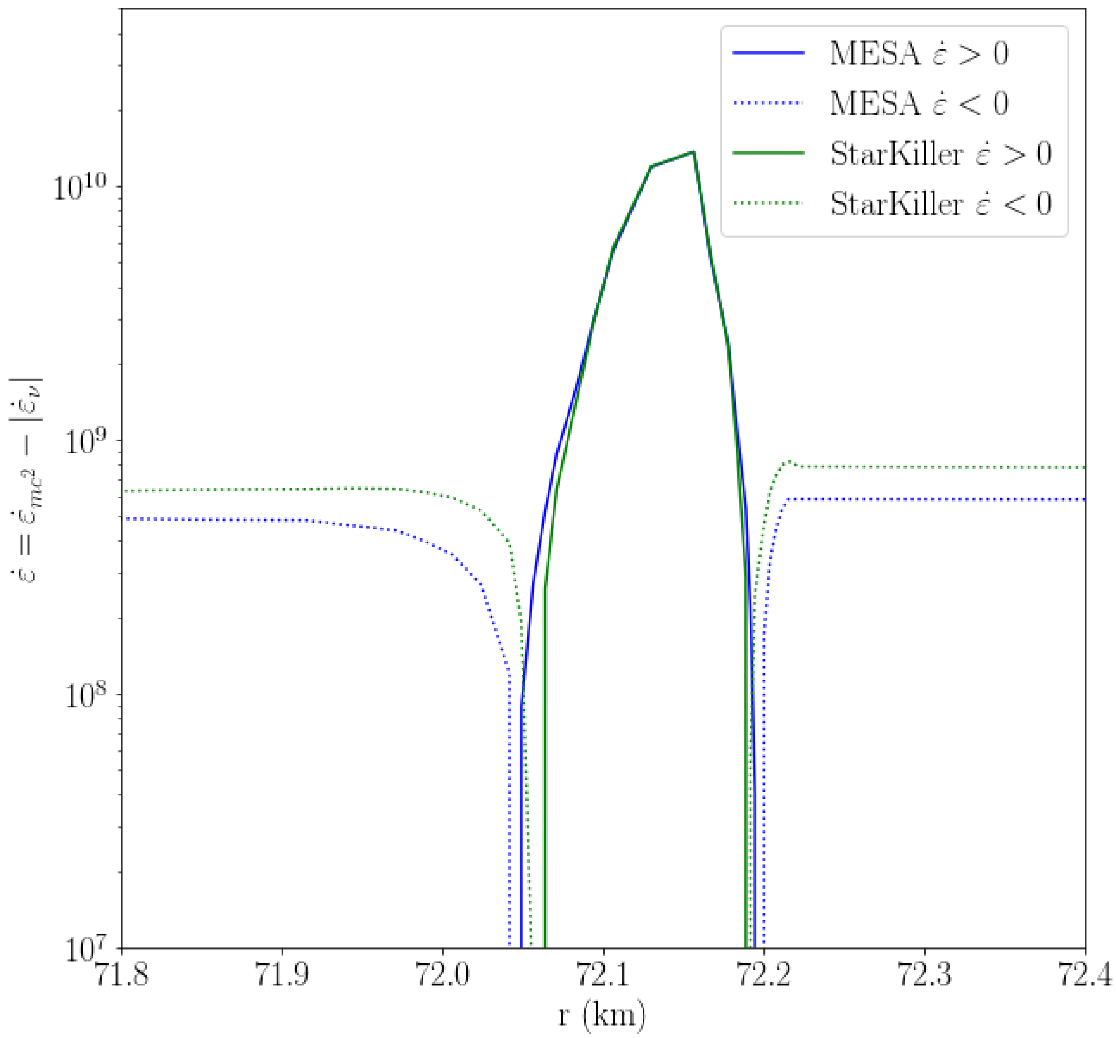

```
In [16]: plot_enuc(ylim=[1.0e-100, 1.0e11])
```



1.4.2 Zoom in on peak temperature

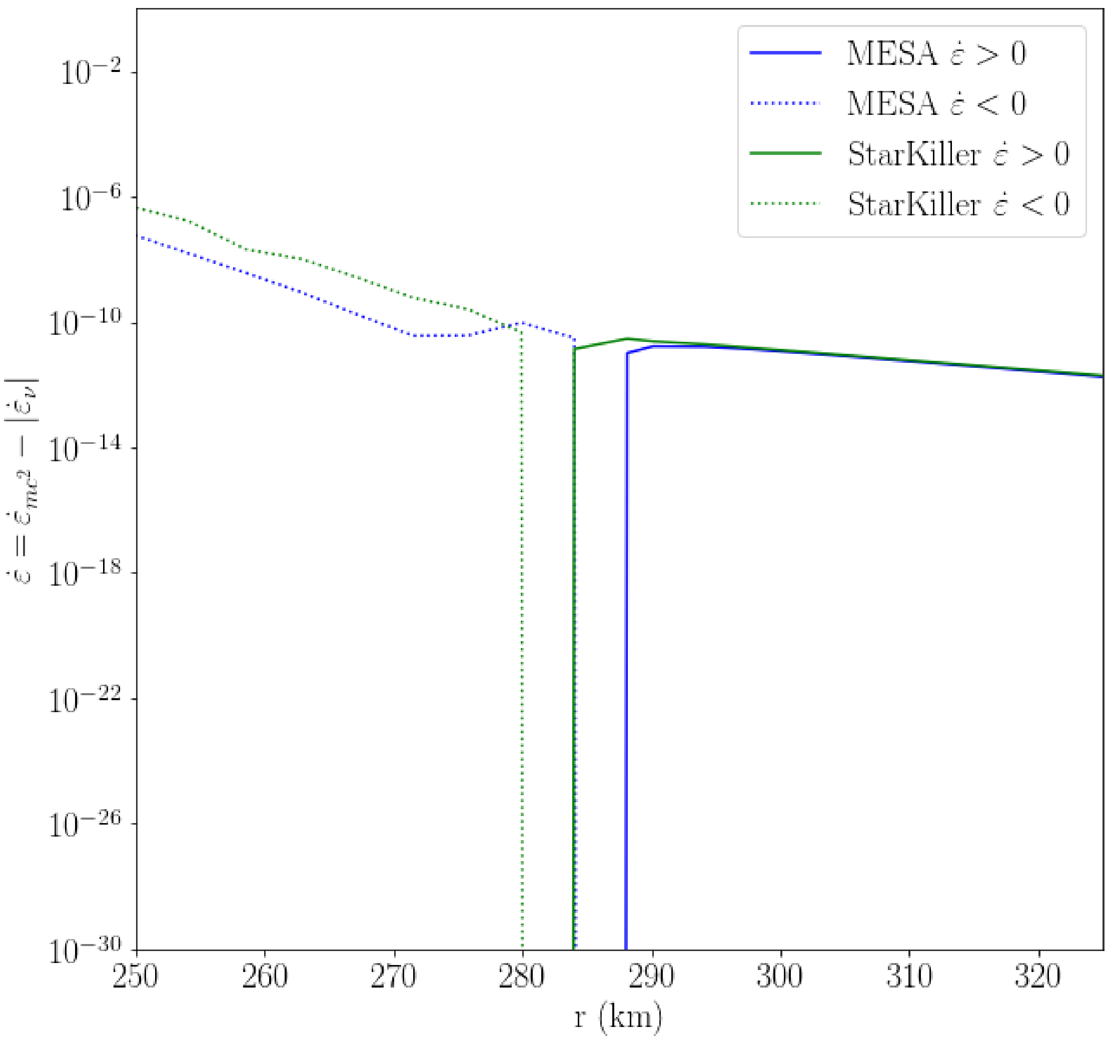
```
In [17]: plot_enuc(xlim=[0.0, 200], ylim=[1.0, 1.0e11])
         plot_enuc(xlim=[71.8, 72.4], ylim=[1.0e7, 5.0e10])
```


MESA $\dot{\varepsilon} > 0$
MESA $\dot{\varepsilon} < 0$
StarKiller $\dot{\varepsilon} > 0$
StarKiller $\dot{\varepsilon} < 0$
$\dot{\varepsilon} = \dot{\varepsilon}_{mc^2} - |\dot{\varepsilon}_\nu|$
r (km)
10^{10}
10^8
10^6
10^4
10^2
10^0
0
25
50
75
100
125
150
175
200



1.4.3 Zoom in on ~300 km radius

```
In [18]: plot_enuc(xlim=[250, 325], ylim=[1.0e-30, 1.0])
```



MESA $\dot{\varepsilon} > 0$
MESA $\dot{\varepsilon} < 0$
StarKiller $\dot{\varepsilon} > 0$
StarKiller $\dot{\varepsilon} < 0$
10^{-2}
10^{-6}
10^{-10}
10^{-14}
10^{-18}
10^{-22}
10^{-26}
10^{-30}
250
260
270
280
290
300
310
320
r (km)
$\dot{\varepsilon} = \dot{\varepsilon}_{mc^2} - |\dot{\varepsilon}_\nu|$