FormFactorsTest

October 8, 2023

```
[1]: import numpy as np
     import NuFF
```

```
[2]: NuFF.get_elements()
```

```
[2]: dict_keys([('NN', 0), ('H', '1'), ('He', '3'), ('He', '4'), ('C', '12'), ('N',
     '14'), ('O', '16'), ('Ne', '20'), ('Mg', '24'), ('Na', '23'), ('Al', '27'),
     ('Si', '28'), ('S', '32'), ('Ar', '40'), ('Ca', '40'), ('Fe', '56'), ('Ni',
     '58')])
```

```
[3]: import sympy as sp
     from IPython.display import display, Math, Latex
```

```
[5]: for el, ms in NuFF.get_elements():
         if(ms != 0):
             print("*************")
             print(el + str(ms))
             print("*************")
             for ff in NuFF.get_form_factors(el,ms):
                 print(ff[1] + '_' + ff[0],":")
                 try:
                     print(NuFF.ff_get_poly(ff[2]))
                     display(Math(sp.latex(NuFF.ff_make_expr(ff[2]))))
                 except:
                     print("couldn't parse ",ff[2])
```

```
*************
H1
*************
M_00 :
poly([0.0397887],y)
```

$$0.0397887$$

```
Sigma_pp_00 :
poly([0.0397887],y)
```

$$0.0397887$$

```
Sigma_p_00 :
poly([0.0795775],y)
```

0.0795775

```
M_11 :
poly([0.0397887],y)
```

0.0397887

```
Sigma_pp_11 :
poly([0.0397887],y)
```

0.0397887

```
Sigma_p_11 :
poly([0.0795775],y)
```

0.0795775

```
M_10 :
poly([0.0397887],y)
```

0.0397887

```
Sigma_pp_10 :
poly([0.0397887],y)
```

0.0397887

```
Sigma_p_10 :
poly([0.0795775],y)
```

0.0795775

```
M_01 :
poly([0.0397887],y)
```

0.0397887

```
Sigma_pp_01 :
poly([0.0397887],y)
```

0.0397887

```
Sigma_p_01 :
poly([0.0795775],y)
```

0.0795775

```
*************
He3
*************
M_00 :
exp(-2y)*poly([0.358099],y)
```

$0.358099e^{-2y}$

```
Sigma_pp_00 :
exp(-2y)*poly([0.0397887],y)
```

$0.0397887e^{-2y}$

```
Sigma_p_00 :
exp(-2y)*poly([0.0795775],y)
```

$0.0795775e^{-2y}$

```
M_11 :
exp(-2y)*poly([0.0397887],y)
```

$0.0397887e^{-2y}$

```
Sigma_pp_11 :
exp(-2y)*poly([0.0397887],y)
```

$0.0397887e^{-2y}$

```
Sigma_p_11 :
exp(-2y)*poly([0.0795775],y)
```

$0.0795775e^{-2y}$

```
M_10 :
exp(-2y)*poly([0.119366],y)
```

$0.119366e^{-2y}$

```
Sigma_pp_10 :
exp(-2y)*poly([-0.0397887],y)
```

$-0.0397887e^{-2y}$

```
Sigma_p_10 :
exp(-2y)*poly([-0.0795775],y)
```

$-0.0795775e^{-2y}$

```
M_01 :
exp(-2y)*poly([0.119366],y)
```

$0.119366e^{-2y}$

```
Sigma_pp_01 :
exp(-2y)*poly([-0.0397887],y)
```

$-0.0397887e^{-2y}$

```
Sigma_p_01 :
exp(-2y)*poly([-0.0795775],y)
```

$-0.0795775e^{-2y}$

```
************
He4
************
```

```
M_00 :
exp(-2y)*poly([0.31831],y)
```

$$0.31831e^{-2y}$$

```
*************
C12
*************
M_00 :
exp(-2y)*poly([ 0.565882   -2.546469    2.86477762],y)
```

$$2.864777625 \left(0.444444444444444y - 1\right)^2 e^{-2y}$$

```
Phi_pp_00 :
exp(-2y)*poly([0.0480805],y)
```

$$0.0480805e^{-2y}$$

```
MPhi_pp_00 :
exp(-2y)*poly([ 0.164948 -0.371134],y)
```

$$\left(0.164948y - 0.371134\right)e^{-2y}$$

```
*************
N14
*************
M_00 :
exp(-2y)*poly([  2.67574 -11.1409    11.6979 ],y)
```

$$\left(2.67574y^2 - 11.1409y + 11.6979\right)e^{-2y}$$

```
Sigma_pp_00 :
exp(-2y)*poly([0.0230079   0.05567268 0.03367807],y)
```

$$0.0336780717644348 \left(0.826541913940456y + 1\right)^2 e^{-2y}$$

```
Sigma_p_00 :
exp(-2y)*poly([ 0.134532   -0.19038377  0.06735568],y)
```

$$0.134532 \left(y - 0.707578\right)^2 e^{-2y}$$

```
Phi_pp_00 :
exp(-2y)*poly([0.0905048],y)
```

$$0.0905048e^{-2y}$$

```
Phi_t_p_00 :
exp(-2y)*poly([0.00126432],y)
```

$$0.00126432e^{-2y}$$

```
Delta_00 :
exp(-2y)*poly([0.0424075],y)
```

$$0.0424075e^{-2y}$$

```
MPhi_pp_00 :
exp(-2y)*poly([ 0.483267 -1.02414 ],y)
```

$$(0.483267y - 1.02414)\, e^{-2y}$$

```
Sigma_ppDelta_00 :
exp(-2y)*poly([-0.0755325  0.0534451],y)
```

$$(0.0534451 - 0.0755325y)\, e^{-2y}$$

```
*************
O16
*************
M_00 :
exp(-2y)*poly([ 3.26280000e-05 -1.30539408e-02  1.33144981e+00 -5.15740313e+00
  5.09294912e+00],y)
```

$$5.09294912430317 \left(0.00253110730882547y^2 - 0.506327768272064y + 1\right)^2 e^{-2y}$$

```
Phi_pp_00 :
exp(-2y)*poly([ 3.26280000e-05 -2.38872851e-04  4.37203007e-04],y)
```

$$0.00043720300699797 \left(0.273182991626941y - 1\right)^2 e^{-2y}$$

```
MPhi_pp_00 :
exp(-2y)*poly([ 3.26280e-05 -6.64641e-03  3.67831e-02 -4.71874e-02],y)
```

$$\left(3.2628 \cdot 10^{-5} y^3 - 0.00664641y^2 + 0.0367831y - 0.0471874\right) e^{-2y}$$

```
*************
Ne20
*************
M_00 :
exp(-2y)*poly([  0.0431723   -0.78151188   4.70902938 -10.61027422
7.95769394],y)
```

$$7.95769394192059 \left(0.0736561436589426y^2 - 0.666667648748582y + 1\right)^2 e^{-2y}$$

```
Phi_pp_00 :
exp(-2y)*poly([ 0.00348077 -0.01740392  0.02175499],y)
```

$$0.0217549865388481 \left(0.3999984000064y - 1\right)^2 e^{-2y}$$

```
MPhi_pp_00 :
exp(-2y)*poly([ 0.0122586 -0.1416     0.443815  -0.416077 ],y)
```

$$\left(0.0122586y^3 - 0.1416y^2 + 0.443815y - 0.416077\right) e^{-2y}$$

```
*************
Mg24
*************
M_00 :
exp(-2y)*poly([  0.123467    -1.85027399   9.31096738 -17.8252621
11.45910386],y)
```

$$11.4591038639066 \left(0.103800661210212y^2 - 0.777777316441506y + 1\right)^2 e^{-2y}$$

```
Phi_pp_00 :
exp(-2y)*poly([ 0.0260816 -0.130408    0.16301  ],y)
```

$$0.16301 \left(0.4y - 1\right)^2 e^{-2y}$$

```
MPhi_pp_00 :
exp(-2y)*poly([ 0.056747 -0.567072  1.6097   -1.36673 ],y)
```

$$\left(0.056747y^3 - 0.567072y^2 + 1.6097y - 1.36673\right) e^{-2y}$$

```
*************
Na23
*************
M_00 :
exp(-2y)*poly([  0.483166  -6.57878    32.5913   -63.4498    42.0965  ],y)
```

$$\left(0.483166y^4 - 6.57878y^3 + 32.5913y^2 - 63.4498y + 42.0965\right) e^{-2y}$$

```
M_11 :
exp(-2y)*poly([ 0.00523012 -0.0543892   0.182941   -0.212207    0.0795776 ],y)
```

$$\left(0.00523012y^4 - 0.0543892y^3 + 0.182941y^2 - 0.212207y + 0.0795776\right) e^{-2y}$$

```
M_10 :
exp(-2y)*poly([-0.04545   0.597822 -2.50445   3.81972  -1.83028 ],y)
```

$$\left(-0.04545y^4 + 0.597822y^3 - 2.50445y^2 + 3.81972y - 1.83028\right) e^{-2y}$$

```
M_01 :
exp(-2y)*poly([-0.04545   0.597822 -2.50445   3.81972  -1.83028 ],y)
```

$$\left(-0.04545y^4 + 0.597822y^3 - 2.50445y^2 + 3.81972y - 1.83028\right) e^{-2y}$$

```
Sigma_pp_00 :
exp(-2y)*poly([ 0.00078605 -0.010514    0.0401886  -0.0262533   0.0126672 ],y)
```

$$\left(0.00078605y^4 - 0.010514y^3 + 0.0401886y^2 - 0.0262533y + 0.0126672\right) e^{-2y}$$

```
Sigma_pp_11 :
exp(-2y)*poly([ 0.00059768 -0.00765719  0.0332751  -0.0167053   0.00917577],y)
```

$$\left(0.000597676y^4 - 0.00765719y^3 + 0.0332751y^2 - 0.0167053y + 0.00917577\right) e^{-2y}$$

```
Sigma_pp_10 :
exp(-2y)*poly([ 0.00062672 -0.00876213  0.0360971  -0.020986    0.0107811 ],y)
```

$$\left(0.000626718y^4 - 0.00876213y^3 + 0.0360971y^2 - 0.020986y + 0.0107811\right) e^{-2y}$$

```
Sigma_pp_01 :
exp(-2y)*poly([ 0.00062672 -0.00876213  0.0360971  -0.020986    0.0107811 ],y)
```

$$\left(0.000626718y^4 - 0.00876213y^3 + 0.0360971y^2 - 0.020986y + 0.0107811\right) e^{-2y}$$

```
Sigma_p_00 :
exp(-2y)*poly([ 0.00466396 -0.0384261   0.100235   -0.0750847   0.0253345 ],y)
```

$$\left(0.00466396y^4 - 0.0384261y^3 + 0.100235y^2 - 0.0750847y + 0.0253345\right)e^{-2y}$$

Sigma_p_11 :
exp(-2y)*poly([0.00477955 -0.0374699   0.0887794 -0.0567009   0.0183515],y)

$$\left(0.00477955y^4 - 0.0374699y^3 + 0.0887794y^2 - 0.0567009y + 0.0183515\right)e^{-2y}$$

Sigma_p_10 :
exp(-2y)*poly([0.00472138 -0.0379511   0.0941439 -0.0652627   0.0215622],y)

$$\left(0.00472138y^4 - 0.0379511y^3 + 0.0941439y^2 - 0.0652627y + 0.0215622\right)e^{-2y}$$

Sigma_p_01 :
exp(-2y)*poly([0.00472138 -0.0379511   0.0941439 -0.0652627   0.0215622],y)

$$\left(0.00472138y^4 - 0.0379511y^3 + 0.0941439y^2 - 0.0652627y + 0.0215622\right)e^{-2y}$$

Phi_pp_00 :
exp(-2y)*poly([0.107832 -0.49308   0.612149],y)

$$\left(0.107832y^2 - 0.49308y + 0.612149\right)e^{-2y}$$

Phi_pp_11 :
exp(-2y)*poly([0.00163204 -0.00747826 0.00940911],y)

$$\left(0.00163204y^2 - 0.00747826y + 0.00940911\right)e^{-2y}$$

Phi_pp_10 :
exp(-2y)*poly([-0.0110124 0.060682 -0.075893],y)

$$\left(-0.0110124y^2 + 0.060682y - 0.075893\right)e^{-2y}$$

Phi_pp_01 :
exp(-2y)*poly([-0.0110124 0.060682 -0.075893],y)

$$\left(-0.0110124y^2 + 0.060682y - 0.075893\right)e^{-2y}$$

Phi_t_p_00 :
exp(-2y)*poly([5.44981e-06 -1.03940e-04 4.95589e-04],y)

$$\left(5.44981 \cdot 10^{-6}y^2 - 0.00010394y + 0.000495589\right)e^{-2y}$$

Phi_t_p_11 :
exp(-2y)*poly([2.84800e-04 8.38100e-05 6.16583e-06],y)

$$\left(0.0002848y^2 + 8.381 \cdot 10^{-5}y + 6.16583 \cdot 10^{-6}\right)e^{-2y}$$

Phi_t_p_10 :
exp(-2y)*poly([3.93968e-05 -3.69894e-04 -5.52785e-05],y)

$$\left(3.93968 \cdot 10^{-5}y^2 - 0.000369894y - 5.52785 \cdot 10^{-5}\right)e^{-2y}$$

Phi_t_p_01 :
exp(-2y)*poly([3.93968e-05 -3.69894e-04 -5.52785e-05],y)

$$\left(3.93968 \cdot 10^{-5}y^2 - 0.000369894y - 5.52785 \cdot 10^{-5}\right)e^{-2y}$$

Delta_00 :
exp(-2y)*poly([0.00656896 -0.0268568   0.0335711],y)

$$\left(0.00656896y^2 - 0.0268568y + 0.0335711\right)e^{-2y}$$

Delta_11 :
exp(-2y)*poly([0.0021619 -0.00617861 0.00772326],y)

$$\left(0.0021619y^2 - 0.00617861y + 0.00772326\right)e^{-2y}$$

Delta_10 :
exp(-2y)*poly([0.00362952 -0.0128817   0.0161021],y)

$$\left(0.00362952y^2 - 0.0128817y + 0.0161021\right)e^{-2y}$$

Delta_01 :
exp(-2y)*poly([0.00362952 -0.0128817   0.0161021],y)

$$\left(0.00362952y^2 - 0.0128817y + 0.0161021\right)e^{-2y}$$

MPhi_pp_00 :
exp(-2y)*poly([0.226345 -2.09908   5.86765 -5.07498],y)

$$\left(0.226345y^3 - 2.09908y^2 + 5.86765y - 5.07498\right)e^{-2y}$$

MPhi_pp_11 :
exp(-2y)*poly([0.00280825 -0.0213121   0.0474719 -0.0273574],y)

$$\left(0.00280825y^3 - 0.0213121y^2 + 0.0474719y - 0.0273574\right)e^{-2y}$$

MPhi_pp_10 :
exp(-2y)*poly([-0.0226015 0.17682   -0.382932   0.220651],y)

$$\left(-0.0226015y^3 + 0.17682y^2 - 0.382932y + 0.220651\right)e^{-2y}$$

MPhi_pp_01 :
exp(-2y)*poly([-0.0210943 0.243236 -0.727336   0.62922],y)

$$\left(-0.0210943y^3 + 0.243236y^2 - 0.727336y + 0.62922\right)e^{-2y}$$

Sigma_ppDelta_00 :
exp(-2y)*poly([0.00476387 -0.0305345   0.0548817 -0.0291634],y)

$$\left(0.00476387y^3 - 0.0305345y^2 + 0.0548817y - 0.0291634\right)e^{-2y}$$

Sigma_ppDelta_11 :
exp(-2y)*poly([0.00310235 -0.0164035   0.0231539 -0.0119052],y)

$$\left(0.00310235y^3 - 0.0164035y^2 + 0.0231539y - 0.0119052\right)e^{-2y}$$

Sigma_ppDelta_10 :
exp(-2y)*poly([0.00481368 -0.02884   0.0482732 -0.024821],y)

$$\left(0.00481368y^3 - 0.02884y^2 + 0.0482732y - 0.024821\right)e^{-2y}$$

Sigma_ppDelta_01 :
exp(-2y)*poly([0.00306717 -0.0171362   0.0263236 -0.013988],y)

$$\left(0.00306717y^3 - 0.0171362y^2 + 0.0263236y - 0.013988\right)e^{-2y}$$

****
Al27

```
*************
M_00 :
exp(-2y)*poly([   1.43446  -18.5981     83.5367   -146.097      87.0146 ],y)
```

$$\left(1.43446y^4 - 18.5981y^3 + 83.5367y^2 - 146.097y + 87.0146\right)e^{-2y}$$

```
M_11 :
exp(-2y)*poly([ 0.018155 -0.132526  0.337291 -0.31831   0.119366],y)
```

$$\left(0.018155y^4 - 0.132526y^3 + 0.337291y^2 - 0.31831y + 0.119366\right)e^{-2y}$$

```
M_10 :
exp(-2y)*poly([-0.11524  1.33587 -4.92756  7.00266 -3.22283],y)
```

$$\left(-0.11524y^4 + 1.33587y^3 - 4.92756y^2 + 7.00266y - 3.22283\right)e^{-2y}$$

```
M_01 :
exp(-2y)*poly([-0.11524  1.33587 -4.92756  7.00266 -3.22283],y)
```

$$\left(-0.11524y^4 + 1.33587y^3 - 4.92756y^2 + 7.00266y - 3.22283\right)e^{-2y}$$

```
Sigma_pp_00 :
exp(-2y)*poly([ 0.0110011  -0.00241606  0.0265347  -0.0367242   0.0309465 ],y)
```

$$\left(0.0110011y^4 - 0.00241606y^3 + 0.0265347y^2 - 0.0367242y + 0.0309465\right)e^{-2y}$$

```
Sigma_pp_11 :
exp(-2y)*poly([ 0.0104813   0.00095354  0.011506   -0.00944476  0.0218834 ],y)
```

$$\left(0.0104813y^4 + 0.000953537y^3 + 0.011506y^2 - 0.00944476y + 0.0218834\right)e^{-2y}$$

```
Sigma_pp_10 :
exp(-2y)*poly([ 0.0105713   0.00060608  0.0158643  -0.0210567   0.0260233 ],y)
```

$$\left(0.0105713y^4 + 0.000606077y^3 + 0.0158643y^2 - 0.0210567y + 0.0260233\right)e^{-2y}$$

```
Sigma_pp_01 :
exp(-2y)*poly([ 0.0105713   0.00060608  0.0158643  -0.0210567   0.0260233 ],y)
```

$$\left(0.0105713y^4 + 0.000606077y^3 + 0.0158643y^2 - 0.0210567y + 0.0260233\right)e^{-2y}$$

```
Sigma_p_00 :
exp(-2y)*poly([ 0.0243737 -0.0942682  0.244466  -0.210848   0.0618929],y)
```

$$\left(0.0243737y^4 - 0.0942682y^3 + 0.244466y^2 - 0.210848y + 0.0618929\right)e^{-2y}$$

```
Sigma_p_11 :
exp(-2y)*poly([ 0.0277477 -0.101991   0.221193  -0.165622   0.0437667],y)
```

$$\left(0.0277477y^4 - 0.101991y^3 + 0.221193y^2 - 0.165622y + 0.0437667\right)e^{-2y}$$

```
Sigma_p_10 :
exp(-2y)*poly([ 0.0259327 -0.0985082  0.233007  -0.18713    0.0520466],y)
```

$$\left(0.0259327y^4 - 0.0985082y^3 + 0.233007y^2 - 0.18713y + 0.0520466\right)e^{-2y}$$

```
Sigma_p_01 :
exp(-2y)*poly([ 0.0259327 -0.0985082  0.233007  -0.18713    0.0520466],y)
```

$$\left(0.0259327y^4 - 0.0985082y^3 + 0.233007y^2 - 0.18713y + 0.0520466\right)e^{-2y}$$

```
Phi_pp_00 :
exp(-2y)*poly([ 0.455491 -2.24306    2.80498 ],y)
```

$$\left(0.455491y^2 - 2.24306y + 2.80498\right)e^{-2y}$$

```
Phi_pp_11 :
exp(-2y)*poly([ 0.00596886 -0.0156159    0.021493  ],y)
```

$$\left(0.00596886y^2 - 0.0156159y + 0.021493\right)e^{-2y}$$

```
Phi_pp_10 :
exp(-2y)*poly([-0.0239615   0.137389   -0.180417 ],y)
```

$$\left(-0.0239615y^2 + 0.137389y - 0.180417\right)e^{-2y}$$

```
Phi_pp_01 :
exp(-2y)*poly([-0.0239615   0.137389   -0.180417 ],y)
```

$$\left(-0.0239615y^2 + 0.137389y - 0.180417\right)e^{-2y}$$

```
Phi_t_p_00 :
exp(-2y)*poly([ 3.40251e-03 -3.76682e-04  6.80703e-05],y)
```

$$\left(0.00340251y^2 - 0.000376682y + 6.80703 \cdot 10^{-5}\right)e^{-2y}$$

```
Phi_t_p_11 :
exp(-2y)*poly([ 0.00440385 -0.00563307  0.0149622 ],y)
```

$$\left(0.00440385y^2 - 0.00563307y + 0.0149622\right)e^{-2y}$$

```
Phi_t_p_10 :
exp(-2y)*poly([ 0.00281525   0.00298228 -0.0010092 ],y)
```

$$\left(0.00281525y^2 + 0.00298228y - 0.0010092\right)e^{-2y}$$

```
Phi_t_p_01 :
exp(-2y)*poly([ 0.00281525   0.00298228 -0.0010092 ],y)
```

$$\left(0.00281525y^2 + 0.00298228y - 0.0010092\right)e^{-2y}$$

```
Delta_00 :
exp(-2y)*poly([ 0.0237577 -0.100835    0.126043 ],y)
```

$$\left(0.0237577y^2 - 0.100835y + 0.126043\right)e^{-2y}$$

```
Delta_11 :
exp(-2y)*poly([ 0.012102 -0.045888   0.05736 ],y)
```

$$\left(0.012102y^2 - 0.045888y + 0.05736\right)e^{-2y}$$

```
Delta_10 :
exp(-2y)*poly([ 0.016845  -0.0680228   0.0850285],y)
```

$$\left(0.016845y^2 - 0.0680228y + 0.0850285\right)e^{-2y}$$

```
Delta_01 :
exp(-2y)*poly([ 0.016845  -0.0680228   0.0850285],y)
```

$$\left(0.016845y^2 - 0.0680228y + 0.0850285\right)e^{-2y}$$

```
MPhi_pp_00 :
exp(-2y)*poly([  0.79705  -7.23234   19.3589  -15.6228 ],y)
```

$$\left(0.79705y^3 - 7.23234y^2 + 19.3589y - 15.6228\right)e^{-2y}$$

```
MPhi_pp_11 :
exp(-2y)*poly([ 0.00866992 -0.0449284   0.0852545  -0.0370794 ],y)
```

$$\left(0.00866992y^3 - 0.0449284y^2 + 0.0852545y - 0.0370794\right)e^{-2y}$$

```
MPhi_pp_10 :
exp(-2y)*poly([-0.0730693  0.491252  -1.00438    0.578632 ],y)
```

$$\left(-0.0730693y^3 + 0.491252y^2 - 1.00438y + 0.578632\right)e^{-2y}$$

```
MPhi_pp_01 :
exp(-2y)*poly([-0.0364952  0.40275   -1.15934    1.00112  ],y)
```

$$\left(-0.0364952y^3 + 0.40275y^2 - 1.15934y + 1.00112\right)e^{-2y}$$

```
Sigma_ppDelta_00 :
exp(-2y)*poly([ 0.0163635 -0.104001   0.185775  -0.0883243],y)
```

$$\left(0.0163635y^3 - 0.104001y^2 + 0.185775y - 0.0883243\right)e^{-2y}$$

```
Sigma_ppDelta_11 :
exp(-2y)*poly([ 0.0131315 -0.0729898  0.114845  -0.0501045],y)
```

$$\left(0.0131315y^3 - 0.0729898y^2 + 0.114845y - 0.0501045\right)e^{-2y}$$

```
Sigma_ppDelta_10 :
exp(-2y)*poly([ 0.0188197 -0.105744   0.170242  -0.0742731],y)
```

$$\left(0.0188197y^3 - 0.105744y^2 + 0.170242y - 0.0742731\right)e^{-2y}$$

```
Sigma_ppDelta_01 :
exp(-2y)*poly([ 0.011398  -0.0717204  0.125323  -0.0595834],y)
```

$$\left(0.011398y^3 - 0.0717204y^2 + 0.125323y - 0.0595834\right)e^{-2y}$$

```
*************
Si28
*************
M_00 :
exp(-2y)*poly([  0.281695    -3.59321128  15.65058632 -26.73668986
15.59656312],y)
```

$$15.5965631183546\left(0.134392525625295y^2 - 0.85713402563403y + 1\right)^2 e^{-2y}$$

```
Phi_pp_00 :
exp(-2y)*poly([ 0.0739103  -0.3695515   0.46193937],y)
```

$$0.461939375\left(0.4y - 1\right)^2 e^{-2y}$$

```
MPhi_pp_00 :
exp(-2y)*poly([ 0.144292 -1.281     3.37434  -2.68415 ],y)
```

$$\left(0.144292y^3 - 1.281y^2 + 3.37434y - 2.68415\right)e^{-2y}$$

```
*************
S32
*************
M_00 :
exp(-2y)*poly([  0.580305    -6.30348182  23.99421681 -37.34775157
20.37155712],y)
```

$$20.3715571208591\left(0.168778080453135y^2 - 0.91666413499546y + 1\right)^2 e^{-2y}$$

```
Phi_pp_00 :
exp(-2y)*poly([ 0.0765941  -0.3829705   0.47871312],y)
```

$$0.478713125\left(0.4y - 1\right)^2 e^{-2y}$$

```
MPhi_pp_00 :
exp(-2y)*poly([ 0.210827 -1.6721    4.11173  -3.12284 ],y)
```

$$\left(0.210827y^3 - 1.6721y^2 + 4.11173y - 3.12284\right)e^{-2y}$$

```
*************
Ar40
*************
M_00 :
exp(-2y)*poly([ 5.44329e-04 -5.95886e-02  1.90360e+00 -1.51940e+01  4.85834e+01
 -6.59618e+01  3.18294e+01],y)
```

$$\left(0.000544329y^6 - 0.0595886y^5 + 1.9036y^4 - 15.194y^3 + 48.5834y^2 - 65.9618y + 31.8294\right)e^{-2y}$$

```
M_11 :
exp(-2y)*poly([ 4.80513e-04 -1.38797e-02  1.41618e-01 -6.22490e-01  1.24846e+00
 -1.06524e+00  3.18304e-01],y)
```

$$\left(0.000480513y^6 - 0.0138797y^5 + 0.141618y^4 - 0.62249y^3 + 1.24846y^2 - 1.06524y + 0.318304\right)e^{-2y}$$

```
M_10 :
exp(-2y)*poly([-5.11426e-04  3.53797e-02 -5.54467e-01  3.19316e+00 -8.02539e+00
  8.62425e+00 -3.18299e+00],y)
```

$$\left(-0.000511426y^6 + 0.0353797y^5 - 0.554467y^4 + 3.19316y^3 - 8.02539y^2 + 8.62425y - 3.18299\right)e^{-2y}$$

```
M_01 :
exp(-2y)*poly([-5.11426e-04  3.53797e-02 -5.54467e-01  3.19316e+00 -8.02539e+00
  8.62425e+00 -3.18299e+00],y)
```

$$\left(-0.000511426y^6 + 0.0353797y^5 - 0.554467y^4 + 3.19316y^3 - 8.02539y^2 + 8.62425y - 3.18299\right)e^{-2y}$$

```
Phi_pp_00 :
exp(-2y)*poly([ 0.00122474 -0.0238983   0.154895   -0.373798    0.299629 ],y)
```

$$\left(0.00122474y^4 - 0.0238983y^3 + 0.154895y^2 - 0.373798y + 0.299629\right)e^{-2y}$$

```
Phi_pp_11 :
exp(-2y)*poly([ 0.00108115 -0.00926264  0.0240755  -0.0181474   0.00414999],y)
```

$$\left(0.00108115y^4 - 0.00926264y^3 + 0.0240755y^2 - 0.0181474y + 0.00414999\right)e^{-2y}$$

Phi_pp_10 :
exp(-2y)*poly([-0.00115071 0.0161561 -0.0683453   0.0990955 -0.0352627],y)

$$\left(-0.00115071y^4 + 0.0161561y^3 - 0.0683453y^2 + 0.0990955y - 0.0352627\right)e^{-2y}$$

Phi_pp_01 :
exp(-2y)*poly([-0.00115071 0.0161561 -0.0683453   0.0990955 -0.0352627],y)

$$\left(-0.00115071y^4 + 0.0161561y^3 - 0.0683453y^2 + 0.0990955y - 0.0352627\right)e^{-2y}$$

MPhi_pp_00 :
exp(-2y)*poly([8.16493e-04 -5.26576e-02 6.53386e-01 -2.89248e+00 5.12625e+00
 -3.08821e+00],y)

$$\left(0.000816493y^5 - 0.0526576y^4 + 0.653386y^3 - 2.89248y^2 + 5.12625y - 3.08821\right)e^{-2y}$$

MPhi_pp_11 :
exp(-2y)*poly([0.00072077 -0.0134973   0.0770456 -0.171917   0.140282
-0.036345],y)

$$\left(0.000720769y^5 - 0.0134973y^4 + 0.0770456y^3 - 0.171917y^2 + 0.140282y - 0.036345\right)e^{-2y}$$

MPhi_pp_10 :
exp(-2y)*poly([-0.00076714 0.0185641 -0.153134   0.515378   -0.709394
0.308826],y)

$$\left(-0.000767139y^5 + 0.0185641y^4 - 0.153134y^3 + 0.515378y^2 - 0.709394y + 0.308826\right)e^{-2y}$$

MPhi_pp_01 :
exp(-2y)*poly([-7.67139e-04 4.52762e-02 -3.73592e-01 1.09117e+00 -1.17124e+00
  3.63444e-01],y)

$$\left(-0.000767139y^5 + 0.0452762y^4 - 0.373592y^3 + 1.09117y^2 - 1.17124y + 0.363444\right)e^{-2y}$$

****
Ca40
****
M_00 :
exp(-2y)*poly([1.67430000e-05 -9.44147816e-03 1.37748971e+00 -1.31465991e+01
  4.52526597e+01 -6.40634111e+01 3.18299405e+01],y)

$$32.2347495935388\left(0.000720699943785404y^3 - 0.203203511250126y^2 + y - 0.993701082491316\right)^2 e^{-2y}$$

Phi_pp_00 :
exp(-2y)*poly([3.76718000e-05 -6.59013894e-04 3.87040677e-03 -8.64428524e-03
  6.48164750e-03],y)

$$0.0064816475048702\left(0.0762369444232675y^2 - 0.666827780742548y + 1\right)^2 e^{-2y}$$

MPhi_pp_00 :
exp(-2y)*poly([2.51146e-05 -7.30079e-03 9.71138e-02 -4.32314e-01 7.59976e-01
 -4.54214e-01],y)

$$\left(2.51146 \cdot 10^{-5}y^5 - 0.00730079y^4 + 0.0971138y^3 - 0.432314y^2 + 0.759976y - 0.454214\right)e^{-2y}$$

```
*************
Fe56
*************
M_00 :
exp(-2y)*poly([ 5.25291e-02 -1.43665e+00  1.44780e+01 -6.72779e+01  1.52644e+02
 -1.60428e+02  6.23888e+01],y)
```

$$\left(0.0525291y^6 - 1.43665y^5 + 14.478y^4 - 67.2779y^3 + 152.644y^2 - 160.428y + 62.3888\right)e^{-2y}$$

```
M_11 :
exp(-2y)*poly([ 0.00921525 -0.122277    0.622264   -1.54562     1.99188
-1.27323
  0.318309 ],y)
```

$$\left(0.00921525y^6 - 0.122277y^5 + 0.622264y^4 - 1.54562y^3 + 1.99188y^2 - 1.27323y + 0.318309\right)e^{-2y}$$

```
M_10 :
exp(-2y)*poly([ -0.0220016   0.446836   -3.2296     10.8919     -18.2579
14.6422
  -4.45633  ],y)
```

$$\left(-0.0220016y^6 + 0.446836y^5 - 3.2296y^4 + 10.8919y^3 - 18.2579y^2 + 14.6422y - 4.45633\right)e^{-2y}$$

```
M_01 :
exp(-2y)*poly([ -0.0220016   0.446836   -3.2296     10.8919     -18.2579
14.6422
  -4.45633  ],y)
```

$$\left(-0.0220016y^6 + 0.446836y^5 - 3.2296y^4 + 10.8919y^3 - 18.2579y^2 + 14.6422y - 4.45633\right)e^{-2y}$$

```
Phi_pp_00 :
exp(-2y)*poly([ 0.069506 -0.867433  3.79067  -6.76595   4.22872 ],y)
```

$$\left(0.069506y^4 - 0.867433y^3 + 3.79067y^2 - 6.76595y + 4.22872\right)e^{-2y}$$

```
Phi_pp_11 :
exp(-2y)*poly([ 0.00486921 -0.0422756   0.144606   -0.229404    0.143378 ],y)
```

$$\left(0.00486921y^4 - 0.0422756y^3 + 0.144606y^2 - 0.229404y + 0.143378\right)e^{-2y}$$

```
Phi_pp_10 :
exp(-2y)*poly([-0.0183967  0.194658  -0.741661   1.24585   -0.778655 ],y)
```

$$\left(-0.0183967y^4 + 0.194658y^3 - 0.741661y^2 + 1.24585y - 0.778655\right)e^{-2y}$$

```
Phi_pp_01 :
exp(-2y)*poly([-0.0183967  0.194658  -0.741661   1.24585   -0.778655 ],y)
```

$$\left(-0.0183967y^4 + 0.194658y^3 - 0.741661y^2 + 1.24585y - 0.778655\right)e^{-2y}$$

```
MPhi_pp_00 :
exp(-2y)*poly([ 0.0604243 -1.20334    8.30471   -25.2342     33.8776
-16.2427   ],y)
```

$$\left(0.0604243y^5 - 1.20334y^4 + 8.30471y^3 - 25.2342y^2 + 33.8776y - 16.2427\right)e^{-2y}$$

```
MPhi_pp_11 :
exp(-2y)*poly([ 0.00669858 -0.0735211   0.308014   -0.622338    0.598168
-0.213631  ],y)
```

$$\left(0.00669858y^5 - 0.0735211y^4 + 0.308014y^3 - 0.622338y^2 + 0.598168y - 0.213631\right)e^{-2y}$$

```
MPhi_pp_10 :
exp(-2y)*poly([-0.0253084  0.325833  -1.54264    3.31473    -3.24853    1.16019
],y)
```

$$\left(-0.0253084y^5 + 0.325833y^4 - 1.54264y^3 + 3.31473y^2 - 3.24853y + 1.16019\right)e^{-2y}$$

```
MPhi_pp_01 :
exp(-2y)*poly([-0.015993  0.288128 -1.74483    4.81422   -6.23805    2.99085 ],y)
```

$$\left(-0.015993y^5 + 0.288128y^4 - 1.74483y^3 + 4.81422y^2 - 6.23805y + 2.99085\right)e^{-2y}$$

```
*************
Ni58
*************
M_00 :
exp(-2y)*poly([ 6.28067e-02 -1.68390e+00   1.66597e+01 -7.61270e+01   1.69877e+02
 -1.75389e+02   6.69246e+01],y)
```

$$\left(0.0628067y^6 - 1.6839y^5 + 16.6597y^4 - 76.127y^3 + 169.877y^2 - 175.389y + 66.9246\right)e^{-2y}$$

```
M_11 :
exp(-2y)*poly([ 0.00545169 -0.0603789   0.250492   -0.503018    0.548985
-0.318305
  0.0795762 ],y)
```

$$\left(0.00545169y^6 - 0.0603789y^5 + 0.250492y^4 - 0.503018y^3 + 0.548985y^2 - 0.318305y + 0.0795762\right)e^{-2y}$$

```
M_10 :
exp(-2y)*poly([ -0.0185041   0.350525   -2.30652    6.95311   -10.3404
7.63937
  -2.30773   ],y)
```

$$\left(-0.0185041y^6 + 0.350525y^5 - 2.30652y^4 + 6.95311y^3 - 10.3404y^2 + 7.63937y - 2.30773\right)e^{-2y}$$

```
M_01 :
exp(-2y)*poly([ -0.0185041   0.350525   -2.30652    6.95311   -10.3404
7.63937
  -2.30773   ],y)
```

$$\left(-0.0185041y^6 + 0.350525y^5 - 2.30652y^4 + 6.95311y^3 - 10.3404y^2 + 7.63937y - 2.30773\right)e^{-2y}$$

```
Phi_pp_00 :
exp(-2y)*poly([ 0.0875404 -1.10715    4.88454   -8.75152    5.4697   ],y)
```

$$\left(0.0875404y^4 - 1.10715y^3 + 4.88454y^2 - 8.75152y + 5.4697\right)e^{-2y}$$

```
Phi_pp_11 :
exp(-2y)*poly([ 0.00140426 -0.00592935  0.0136707  -0.0156476   0.00977975],y)
```

$$\left(0.00140426y^4 - 0.00592935y^3 + 0.0136707y^2 - 0.0156476y + 0.00977975\right)e^{-2y}$$

```
Phi_pp_10 :
exp(-2y)*poly([-0.0110873  0.0935201 -0.264922   0.370054  -0.231284 ],y)
```

$$\left(-0.0110873y^4 + 0.0935201y^3 - 0.264922y^2 + 0.370054y - 0.231284\right)e^{-2y}$$

```
Phi_pp_01 :
exp(-2y)*poly([-0.0110873  0.0935201 -0.264922   0.370054  -0.231284 ],y)
```

$$\left(-0.0110873y^4 + 0.0935201y^3 - 0.264922y^2 + 0.370054y - 0.231284\right)e^{-2y}$$

```
MPhi_pp_00 :
exp(-2y)*poly([  0.0741493  -1.4629      10.0435     -30.3339      40.3764
-19.1326   ],y)
```

$$\left(0.0741493y^5 - 1.4629y^4 + 10.0435y^3 - 30.3339y^2 + 40.3764y - 19.1326\right)e^{-2y}$$

```
MPhi_pp_11 :
exp(-2y)*poly([ 0.00276687 -0.0211633   0.0607914  -0.0956406   0.0781112
-0.0278969 ],y)
```

$$\left(0.00276687y^5 - 0.0211633y^4 + 0.0607914y^3 - 0.0956406y^2 + 0.0781112y - 0.0278969\right)e^{-2y}$$

```
MPhi_pp_10 :
exp(-2y)*poly([-0.0218459  0.25912    -1.10461     2.0953     -1.84727     0.659741
],y)
```

$$\left(-0.0218459y^5 + 0.25912y^4 - 1.10461y^3 + 2.0953y^2 - 1.84727y + 0.659741\right)e^{-2y}$$

```
MPhi_pp_01 :
exp(-2y)*poly([-0.00939131  0.145722   -0.692274    1.48687     -1.7073
0.809015   ],y)
```

$$\left(-0.00939131y^5 + 0.145722y^4 - 0.692274y^3 + 1.48687y^2 - 1.7073y + 0.809015\right)e^{-2y}$$

```
[ ]:
```