Iterative Simulations of LHC Beam With a Carbon Target

By

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Design Parameters of the LHC Beam

LHC will provide two counter rotating 7 TeV proton beams

Each beam will consist of 2808 proton bunches

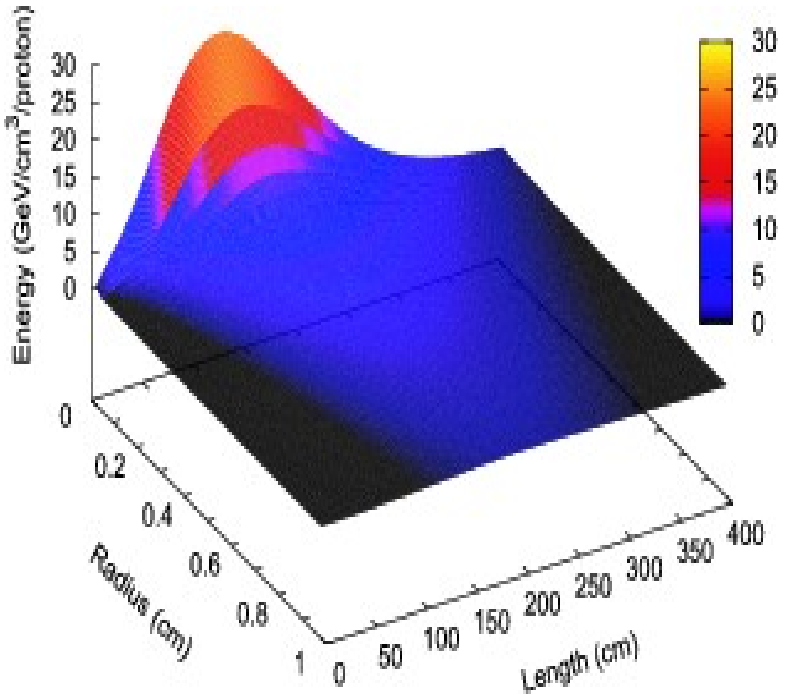
Each bunch will contain 1.15×10^{11} protons

Total number of protons is 3×10^{14}

Bunch length = 0.5 ns, Separation between bunches = 25 ns

Total length of the bunch train = 89 μs

Transverse intensity distribution: Gaussian with $\sigma = 0.2$ mm

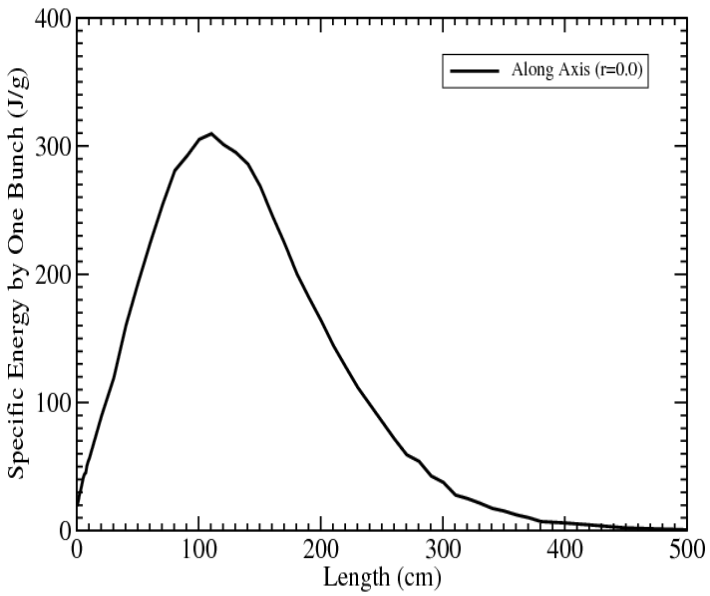


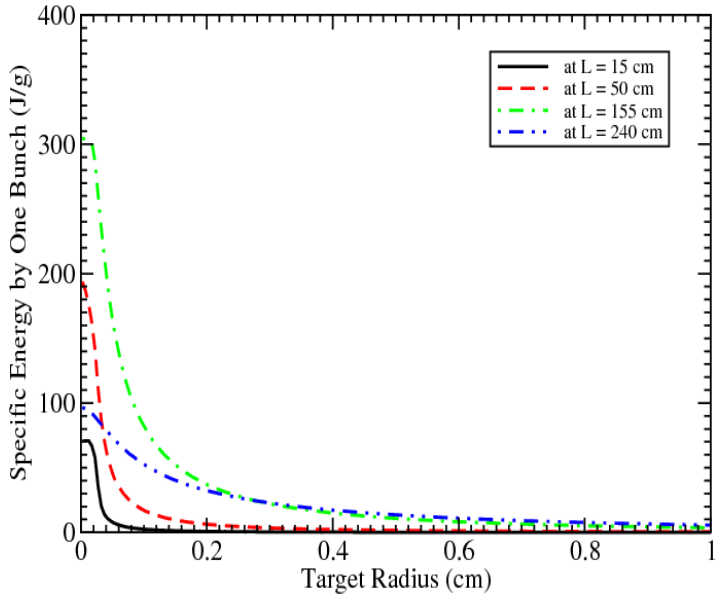
II: LHC Beam on a Carbon target

For FLUKA Calculations: **L = 5 m, r = 1 m**

For Hydrodynamic simulations:

L = 10 m, r = 2.5 cm





Specific Energy

C	Cu
0.3 kJ/g	2.3 kJ/g

Previous Calculations Using Analytic Approximation

N.A. Tahir et al., Laser Part. Beams 27 (2009) 475

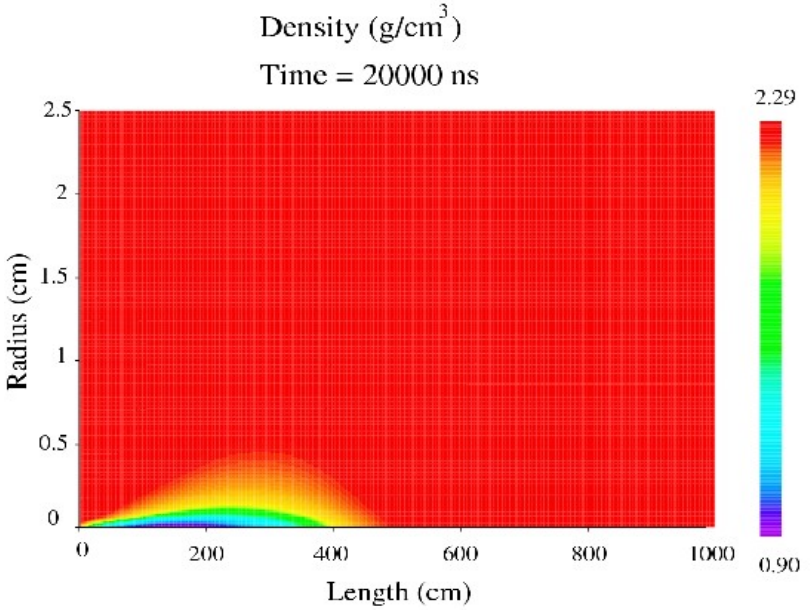
- **The target is studied in r-Z geometry.**
- **Specific energy deposition in each simulation cell at every timestep is normalized with respect to the line density along the axis.**
- **This allows for reduction of specific energy deposition in low density part of the target.**
- **This model allows for studying the proton "Tunneling Effect".**

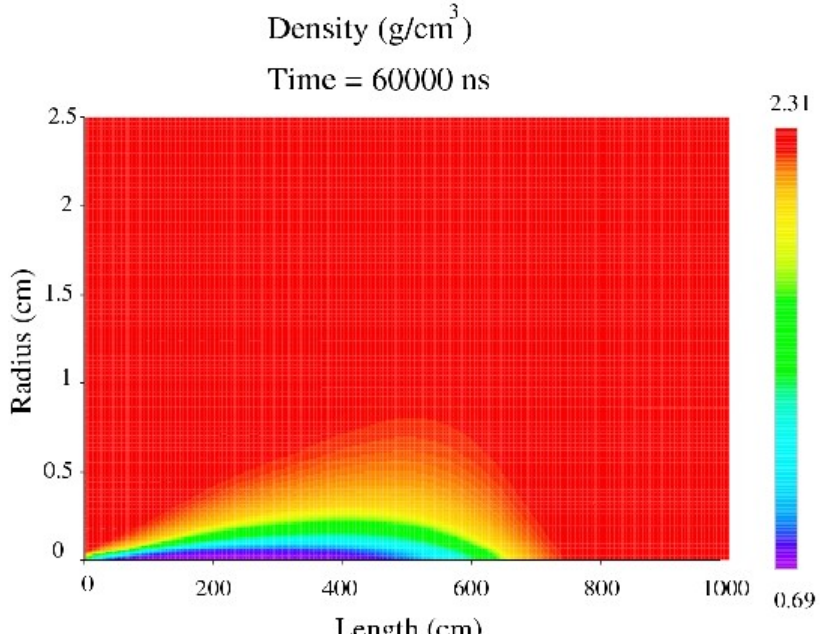
I : **LHC Beam on a Solid Carbon Cylinder**

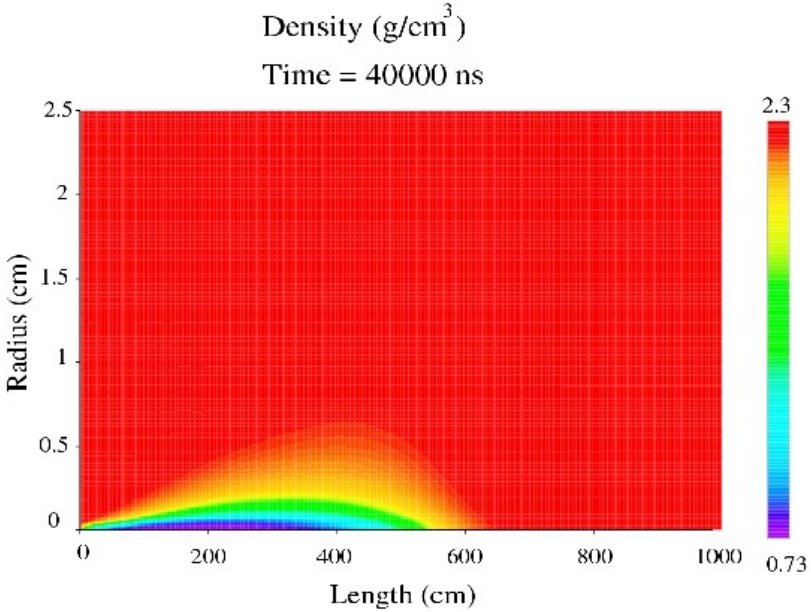
L = 10 m

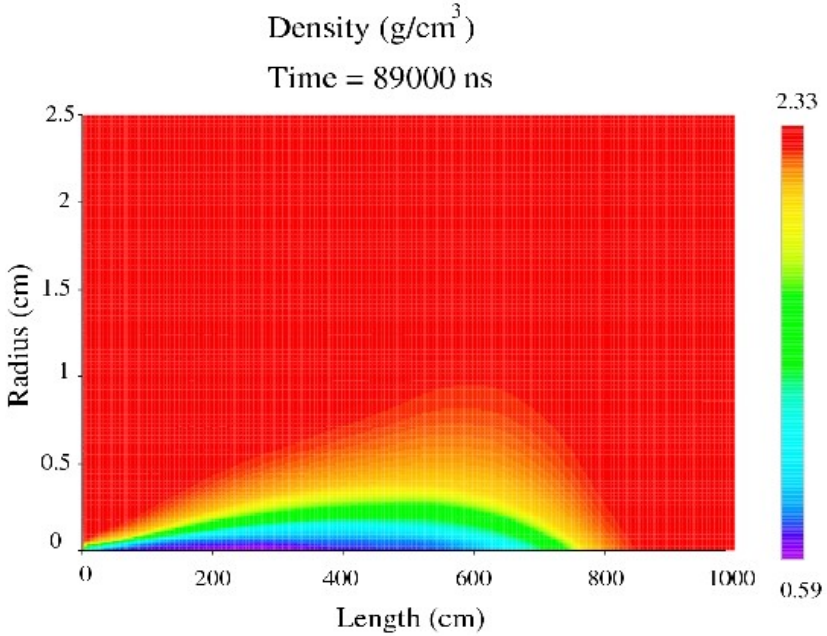
r = 2.5 cm

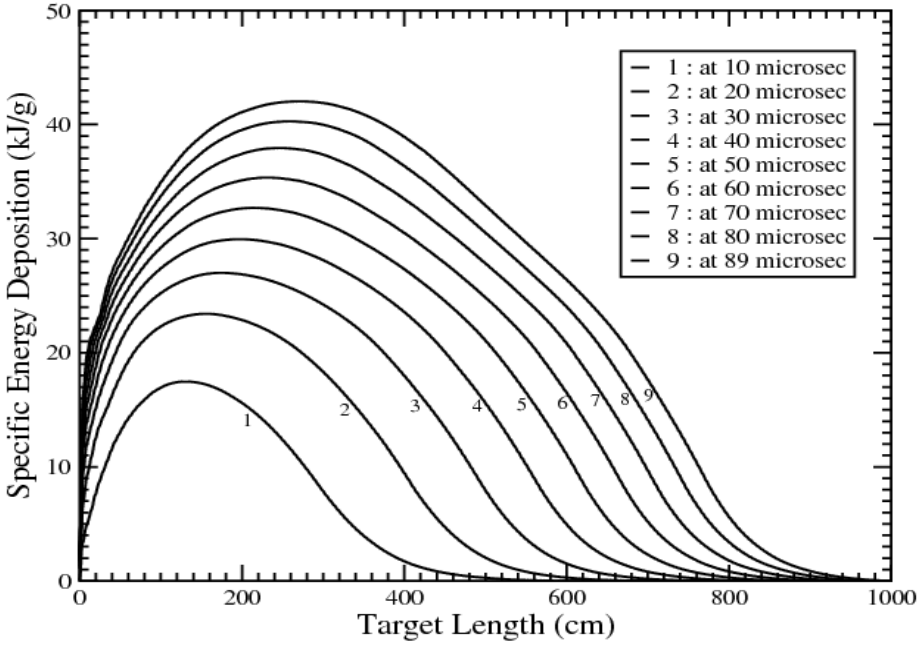
Density

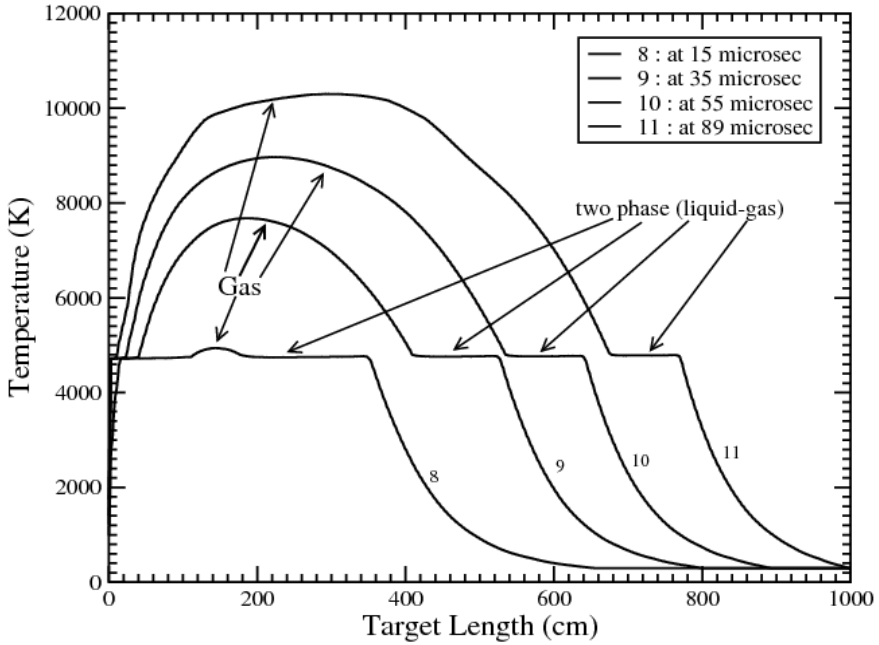

Density (g/cm3)
Time = 20000 ns
2.29
0.90
Radius (cm)
Length (cm)
0
0.5
1
1.5
2
2.5
0
200
400
600
800
1000

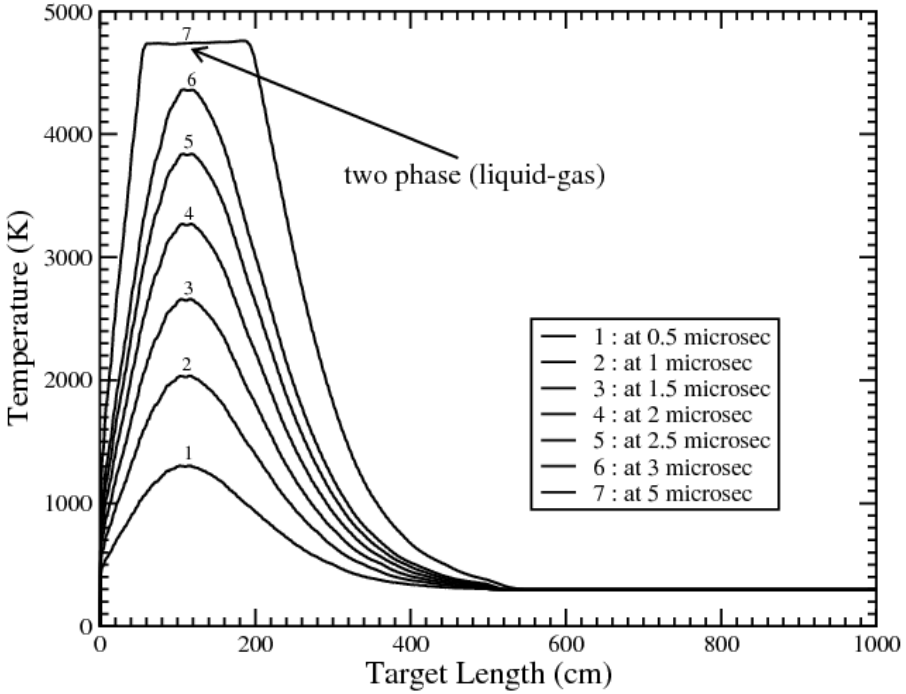

Density (g/cm3)
Time = 60000 ns
2.31
0.69
Radius (cm)
Length (cm)
0
0.5
1
1.5
2
2.5
0
200
400
600
800
1000

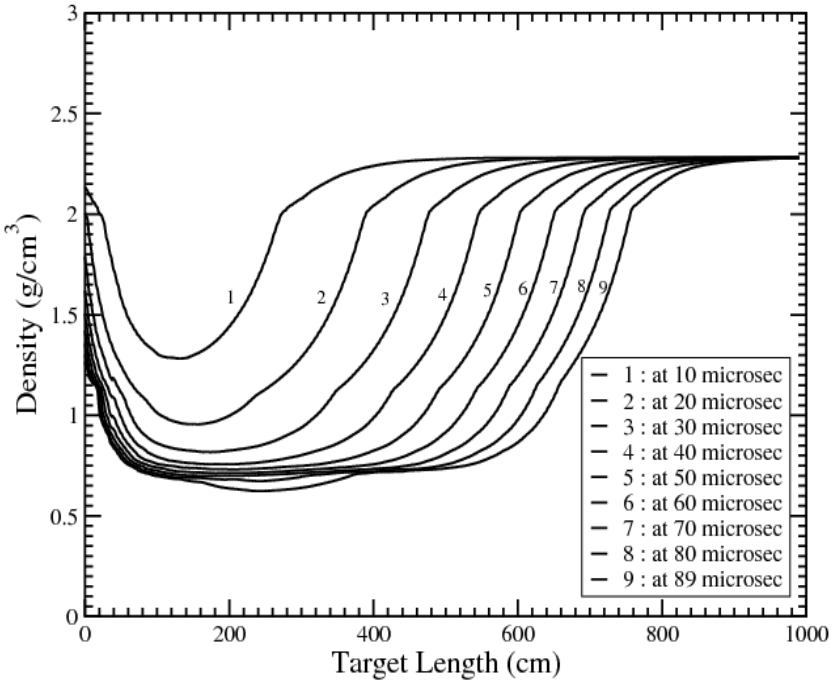

Density (g/cm3)
Time = 40000 ns
2.3
0.73
Radius (cm)
Length (cm)
0
0.5
1
1.5
2
2.5
0
200
400
600
800
1000


Density (g/cm3)
Time = 89000 ns
2.33
0.59
Radius (cm)
Length (cm)
0
0.5
1
1.5
2
2.5
0
200
400
600
800
1000


Specific Energy Deposition (kJ/g)
Target Length (cm)
1 : at 10 microsec
2 : at 20 microsec
3 : at 30 microsec
4 : at 40 microsec
5 : at 50 microsec
6 : at 60 microsec
7 : at 70 microsec
8 : at 80 microsec
9 : at 89 microsec

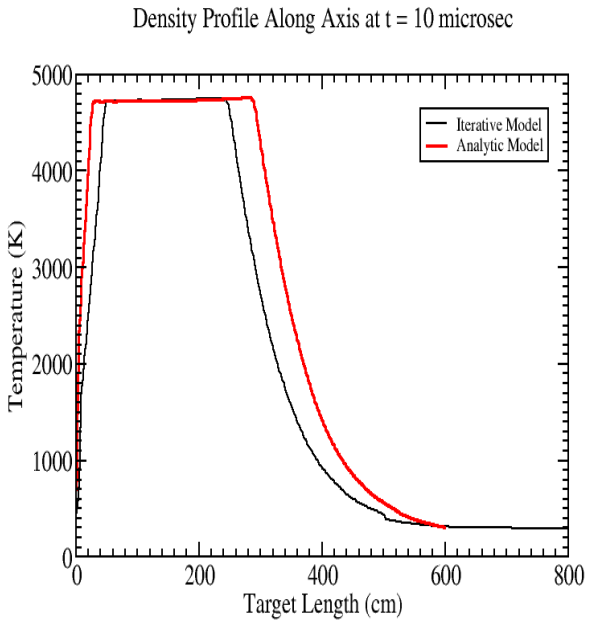

Temperature (K)
Target Length (cm)
8 : at 15 microsec
9 : at 35 microsec
10 : at 55 microsec
11 : at 89 microsec
two phase (liquid-gas)
Gas

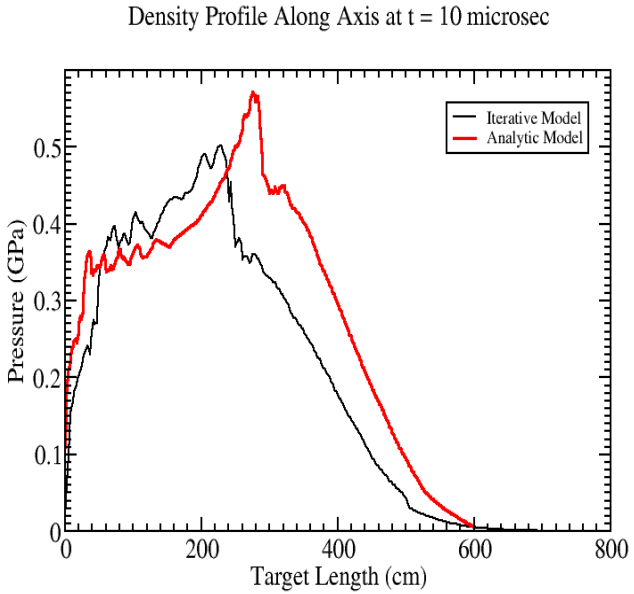

Temperature (K)
Target Length (cm)
two phase (liquid-gas)
1 : at 0.5 microsec
2 : at 1 microsec
3 : at 1.5 microsec
4 : at 2 microsec
5 : at 2.5 microsec
6 : at 3 microsec
7 : at 5 microsec

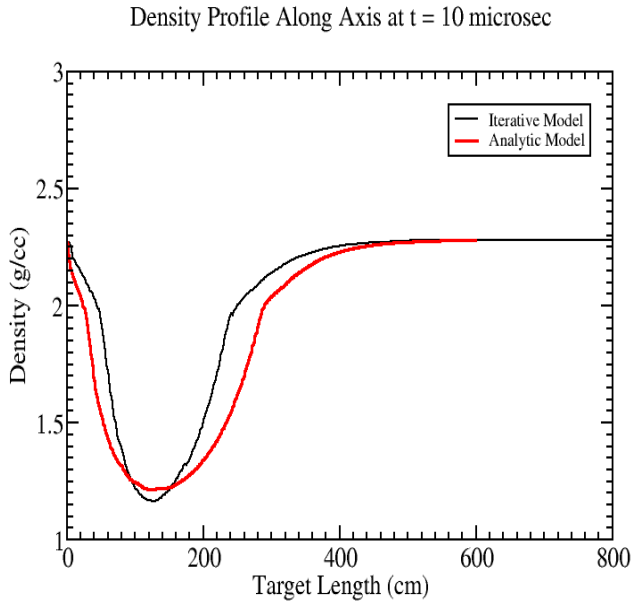

Density (g/cm3)
Target Length (cm)
1 : at 10 microsec
2 : at 20 microsec
3 : at 30 microsec
4 : at 40 microsec
5 : at 50 microsec
6 : at 60 microsec
7 : at 70 microsec
8 : at 80 microsec
9 : at 89 microsec

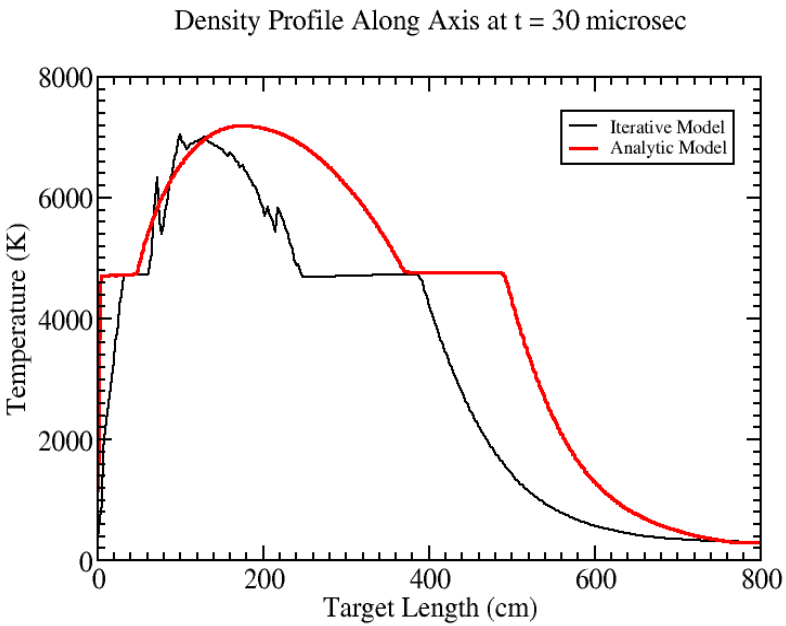
Running FLUKA and BIG2 Iteratively

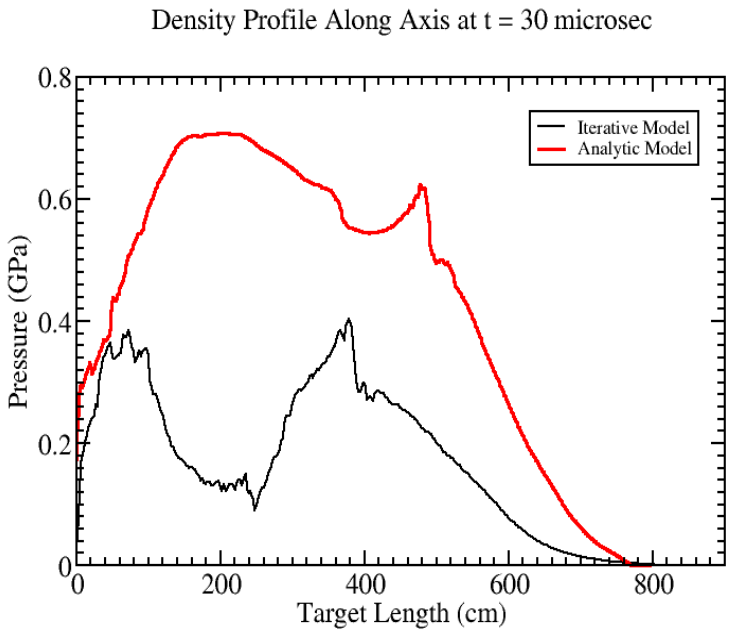
In case of carbon we run FLUKA and BIG2 using time interval of 5μs.

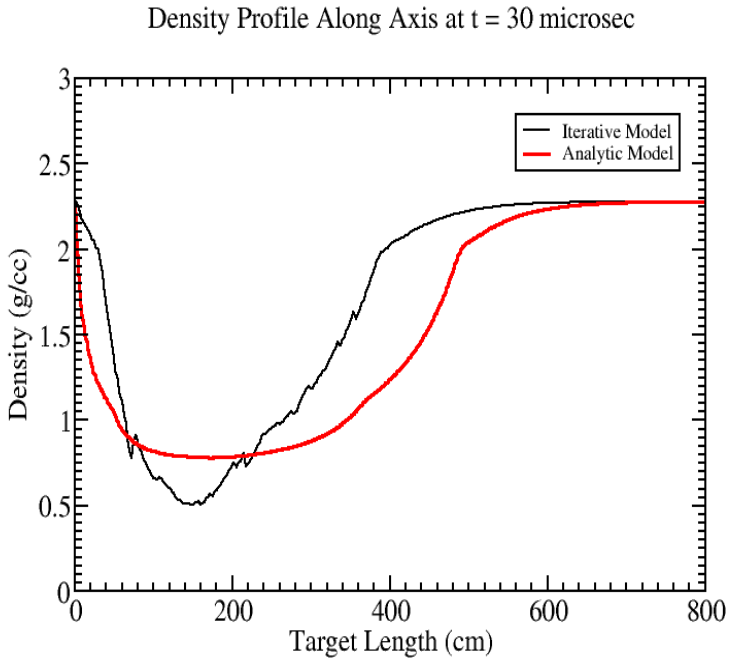


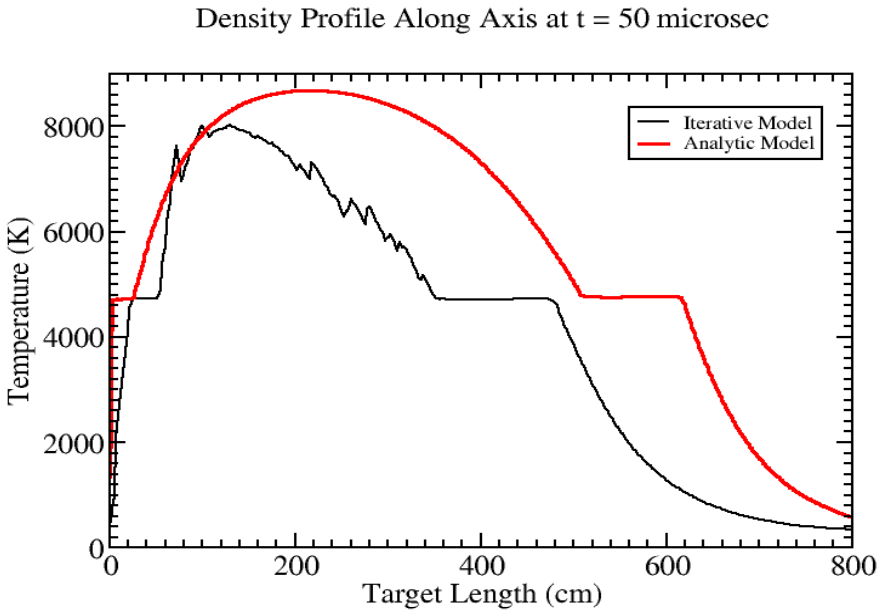


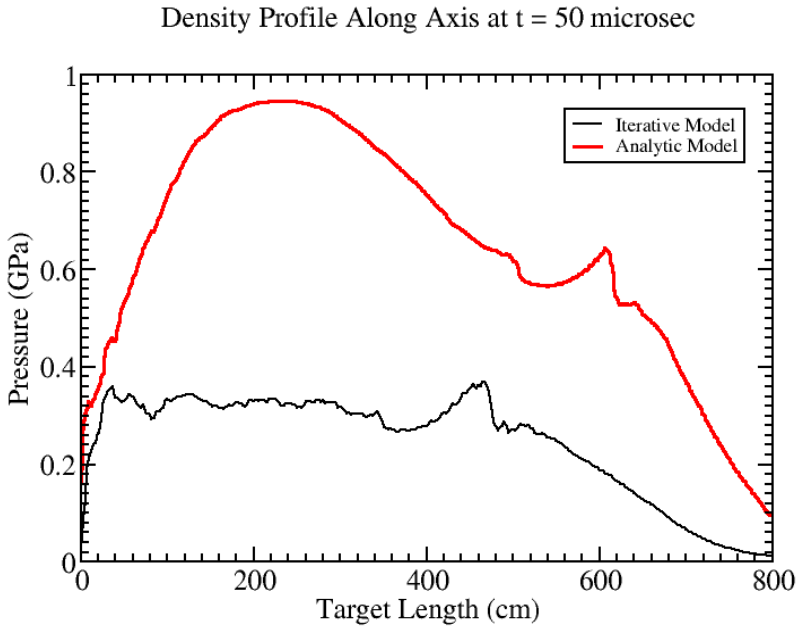


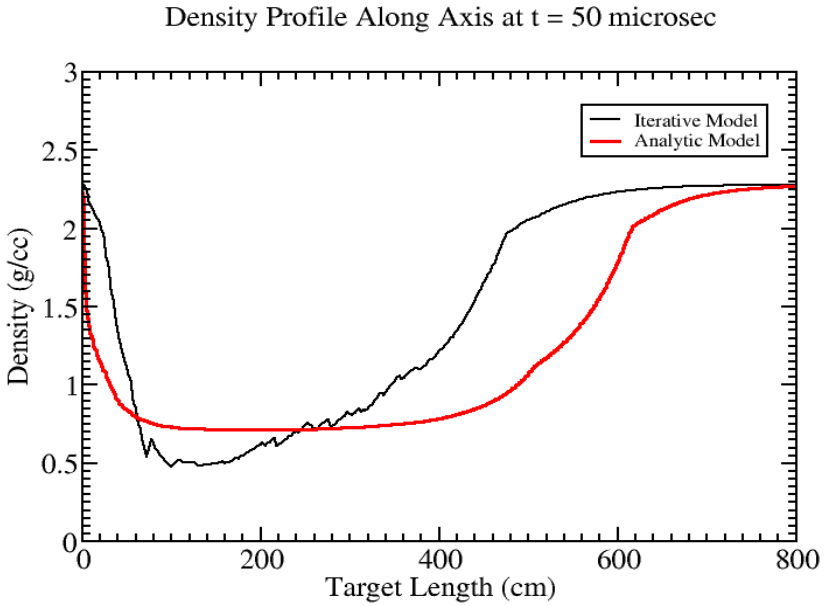

Density Profile Along Axis at t = 30 microsec
Iterative Model
Analytic Model
Temperature (K)
Target Length (cm)
0
2000
4000
6000
8000
0
200
400
600
800


Density Profile Along Axis at t = 30 microsec
Iterative Model
Analytic Model
Pressure (GPa)
Target Length (cm)
0
0.2
0.4
0.6
0.8
0
200
400
600
800


Density Profile Along Axis at t = 30 microsec
Iterative Model
Analytic Model
Density (g/cc)
Target Length (cm)
0
0.5
1
1.5
2
2.5
3
0
200
400
600
800







Differences are obvious in the results obtained using the analytic approximation and the iterative running approach.

After completion of C target calculations, Cu target will be considered