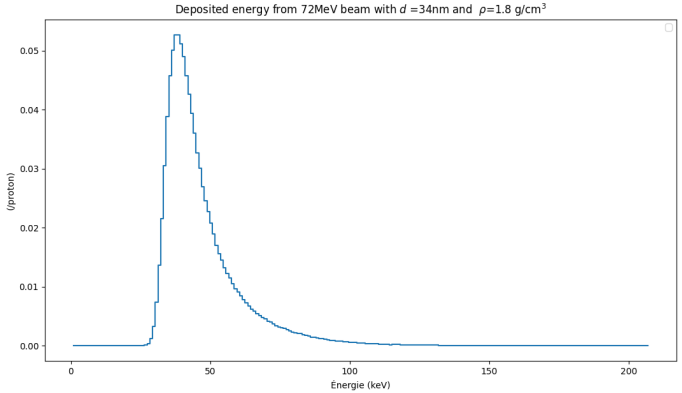
February Work

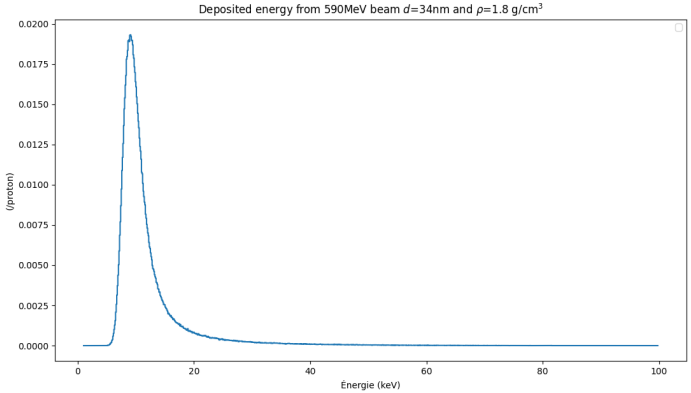
Fluka simulations, A. Abouelenain, February 2024

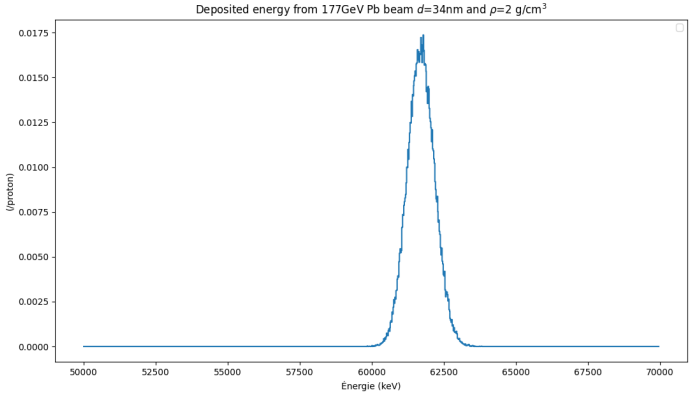
Protons and Lead ions

- Protons beam of energies 72MeV & 590MeV
- Lead ions Pb of energy 177 MeV/u
- Wire of diameter 34 micrometer and densities of 1.8 & 2 g/cm^3

Energy deposition







graphite d=1,8	protons at 72 MeV				
	ATIMA (keV)	FLUKA (keV) E > 1keV	FLUKA (keV) proton contrib.	FLUKA (keV) electron contrib.	FLUKA (keV) 1 < E < 100
	51	48.189	34.06	13.713	46.684

graphite d=2	protons at 72 MeV				
	ATIMA (keV)	FLUKA (keV) E > 1keV	FLUKA (keV) proton contrib.	FLUKA (keV) electron contrib.	FLUKA (keV) 1 < E < 100
	56	53.76	37.848	15.438	51.28

	protons at 590 MeV				
ATIMA (keV)	FLUKA (keV) E > 1keV	FLUKA (keV) proton contrib.	FLUKA (keV) electron contrib.	FLUKA (keV) 1 < E < 100	
14	12.382	8.9323	3.1168	11.955	

	protons at 590 MeV				
ATIMA (keV)	FLUKA (keV) E > 1keV	FLUKA (keV) proton contrib.	FLUKA (keV) electron contrib.	FLUKA (keV) 1 < E < 100	
15	13.721	9.9181	3.5155	13.336	

graphite d=1,8	Pb HI at 177,4 GeV/u				
	ATIMA (MeV)	FLUKA (MeV) E > 1keV	FLUKA (MeV) Ion contrib.	FLUKA (MeV) electron contrib.	FLUKA (MeV) 1 < E < 100
Delta-ray threshold at 1 keV	90.763	55.695	42.561	13.134	55.6843
Delta-ray threshold at 1 MeV		64.384	64.369	0.014539	64.368

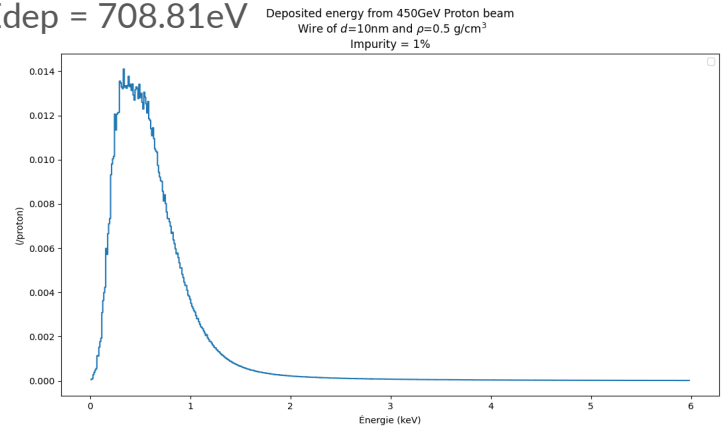
graphite d=2	Pb HI at 177,4 GeV/u				
	ATIMA (MeV)	FLUKA (keV) E > 1keV	FLUKA (keV) proton contrib.	FLUKA (MeV) electron contrib.	FLUKA (keV) 1 < E < 100
Delta-ray threshold at 1 keV	100.848	61.732	46.921	14.812	61.7225
Delta-ray threshold at 1 MeV		71.173	71.155	0.017927	71.1651

Protons of energy 450 GeV

Range	Measurements	
Density	0.5-2	0.5 - 1 - 1.5 - 2
Diameter	1 - 10 um	1- 2- 4 - 6 - 8 -10
Percentage of impurities	1-10 %	1-2-4-6-8-10
Energy	450 Gev	450 Gev

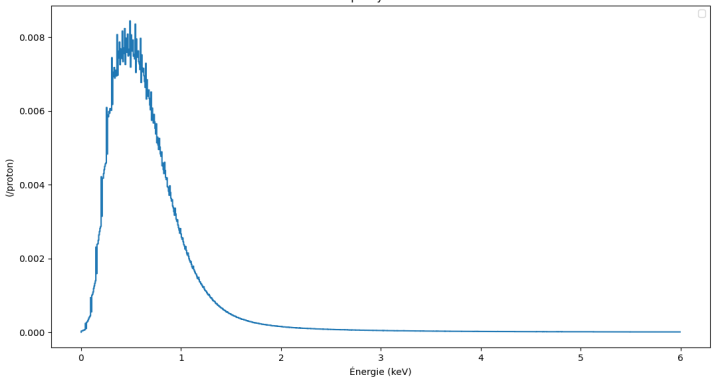
Diameter = 10 micrometers

Edep = 708.81eV

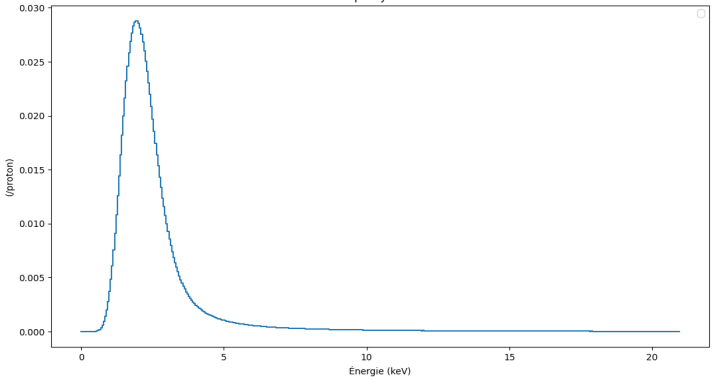


Deposited energy from 450GeV Proton beam
Wire of d=10nm and ρ=0.5 g/cm^3
Impurity = 10%

Edep=768.80 eV

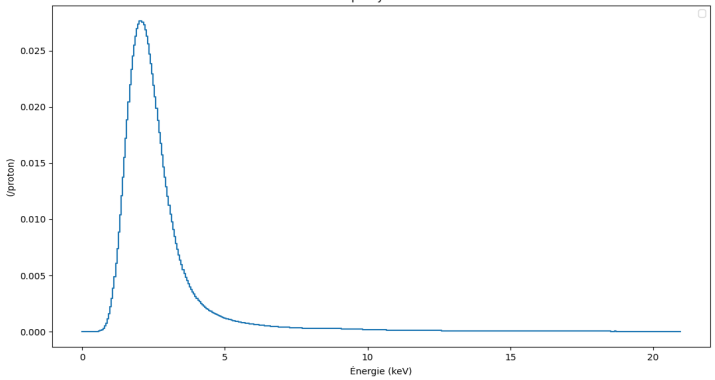


Edep = 2.77 keV



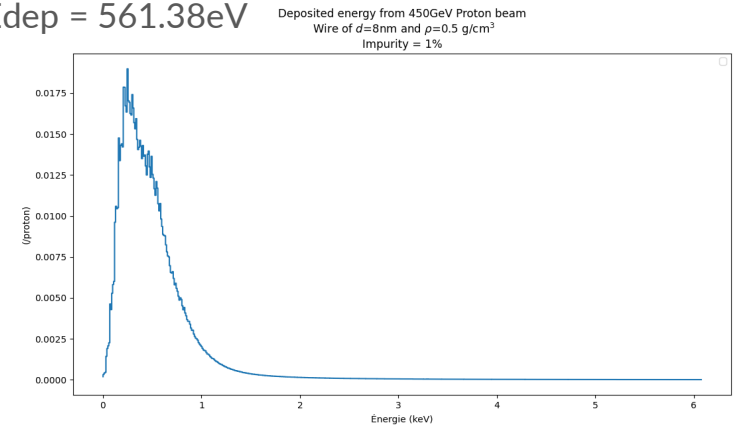
Deposited energy from 450GeV Proton beam
Wire of d=10nm and ρ=2 g/cm^3
Impurity = 10%

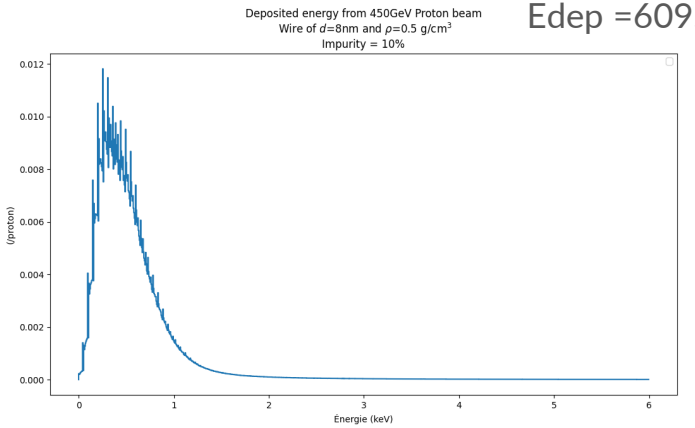
Edep = 2.95 keV



Diameter = 8 micrometers

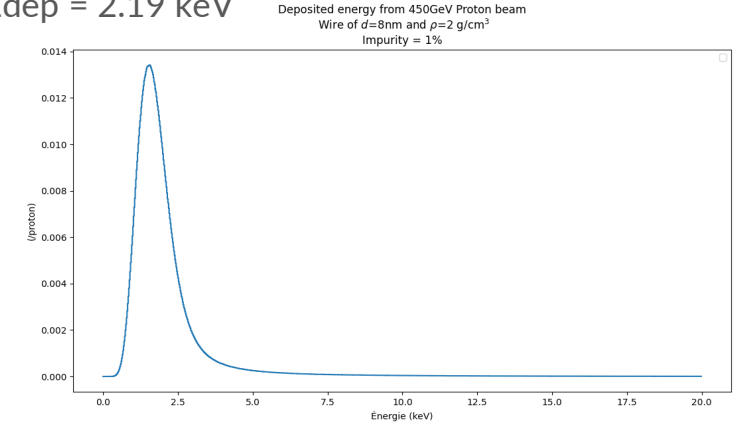
Edep = 561.38eV

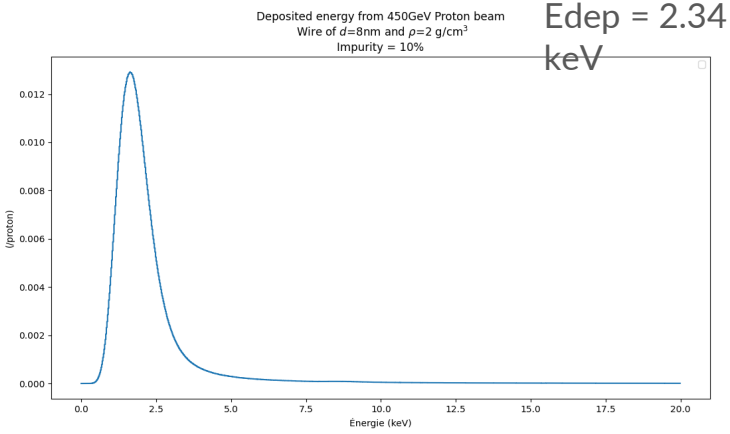




Edep =609.44 eV

Edep = 2.19 keV

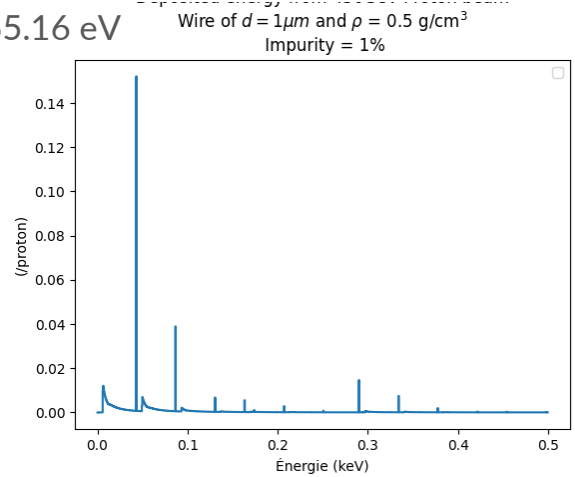




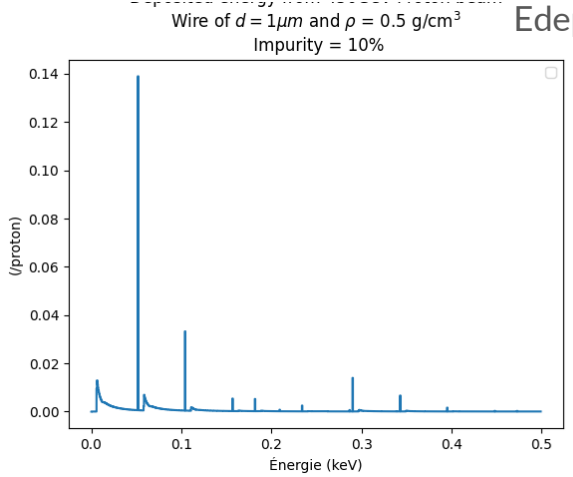
Edep = 2.34 keV

Diameter = 1 micrometers

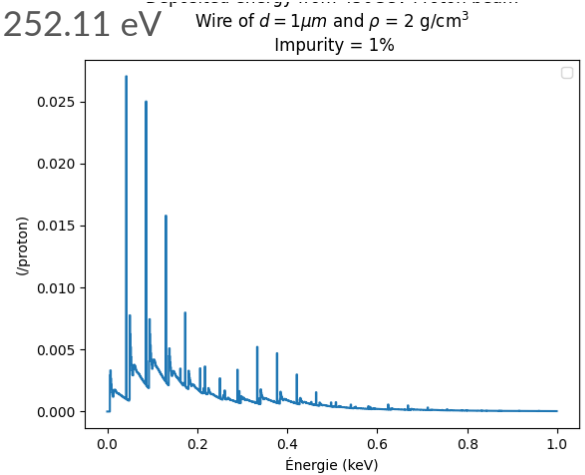
Edep= 65.16 eV



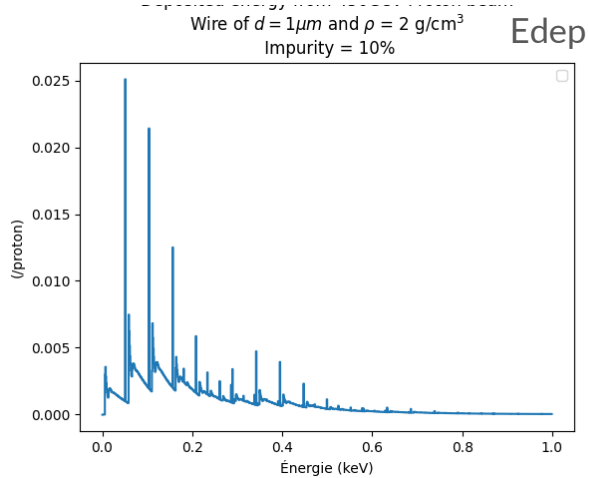
Edep = 70.69 eV



Edep = 252.11 eV



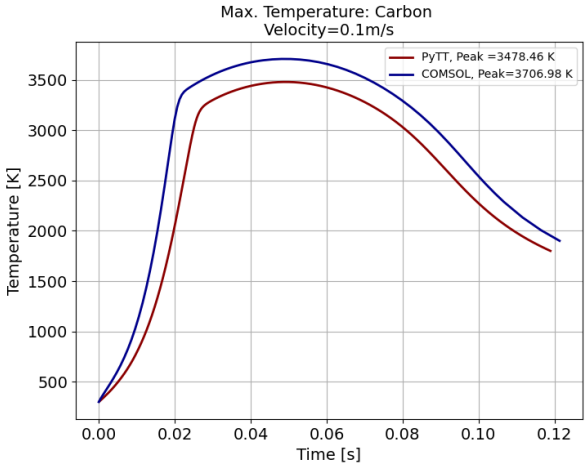
Edep = 267.93 eV

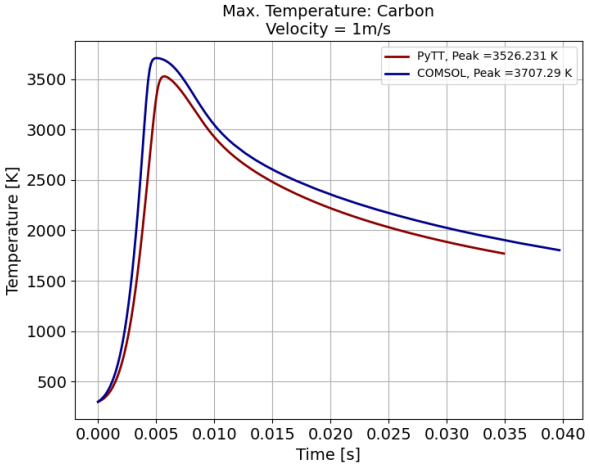


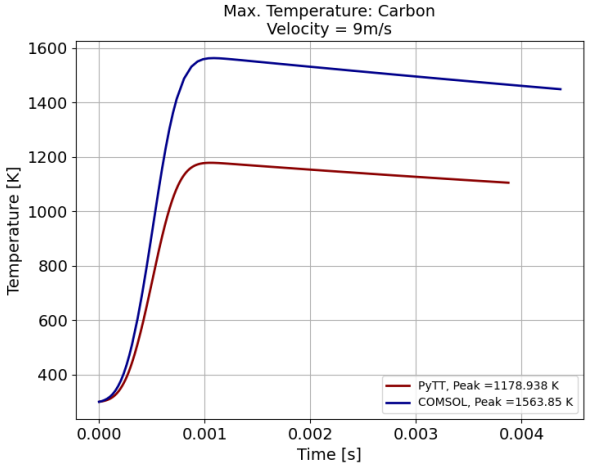
Temperature simulations

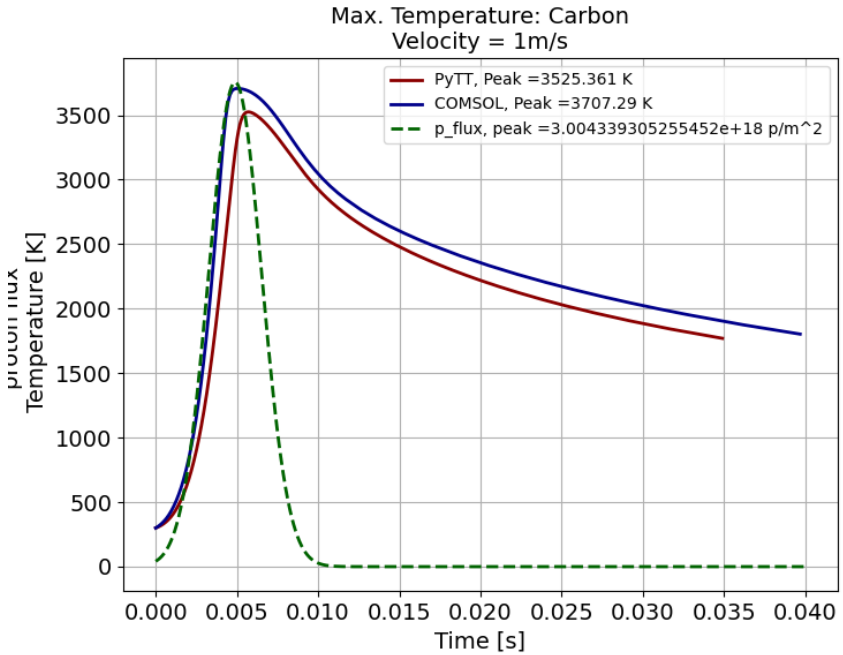
Parameters	Values
Beam energy	450 GeV
Energy deposited by a proton	7640 eV - 1.42 MeV cm^2 /g
Wire's density	1.8 g/cm^3
Wire diameter	30 um
Beam σ_x	1.63 mm
Beam σ_y	0.65 mm
Revolution time τ	2.3×10^{-5} s
protons in beam	2×10^{13}
Scan direction	Horizontal

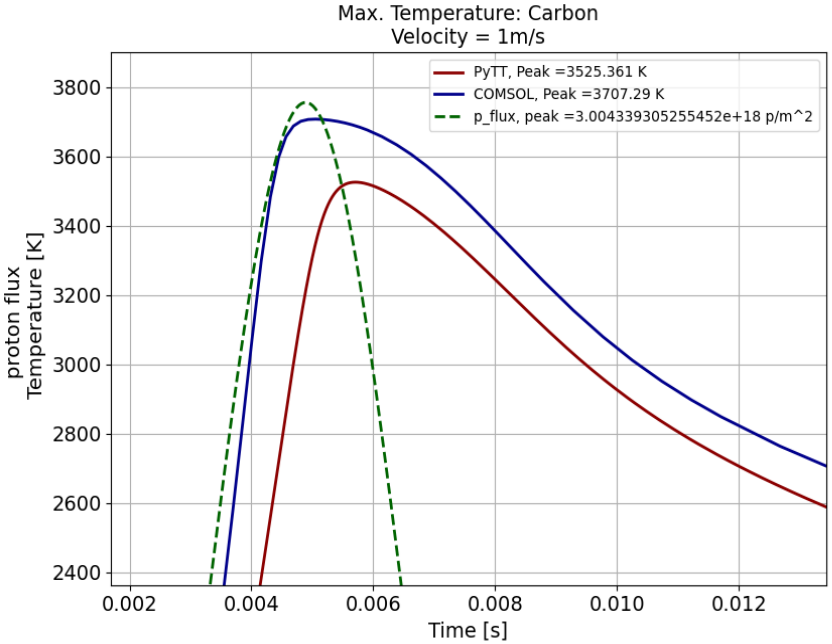
Three Velocities



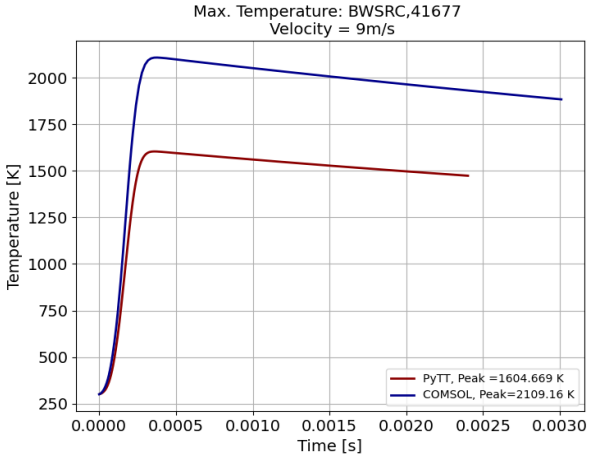


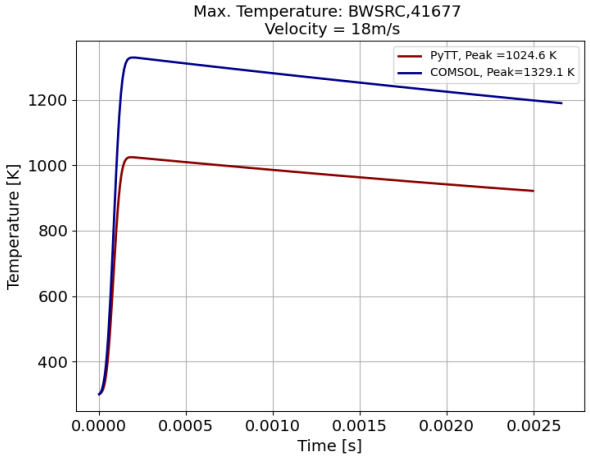



Max. Temperature: Carbon
Velocity = 1m/s
PyTT, Peak =3525.361 K
COMSOL, Peak =3707.29 K
p_flux, peak =3.004339305255452e+18 p/m^2
proton flux
Temperature [K]
Time [s]


Max. Temperature: Carbon
Velocity = 1m/s
PyTT, Peak =3525.361 K
COMSOL, Peak =3707.29 K
p_flux, peak =3.004339305255452e+18 p/m^2
proton flux
Temperature [K]
Time [s]

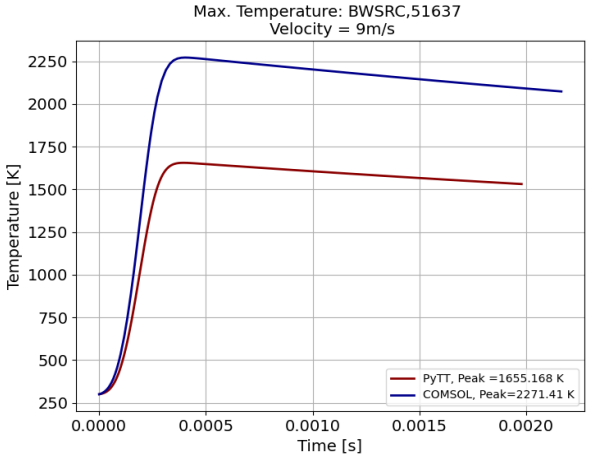
BWSRC,41677

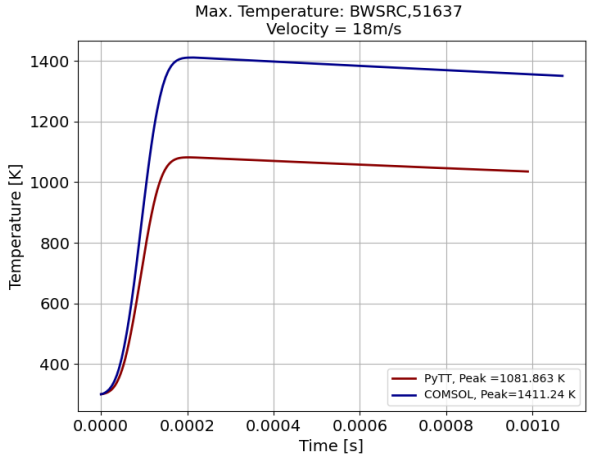




Parameters	Values
Beam σ_x	0.4566 mm
Beam σ_y	0.5366 mm
Revolution time τ	2.3×10^{-5} s
protons in beam	2.16×10^{13}
Scan direction	Vertical

BWSRC,51637



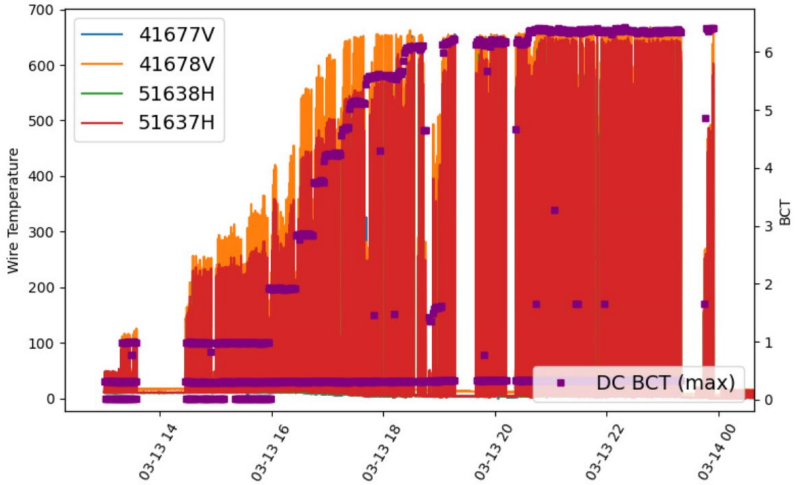


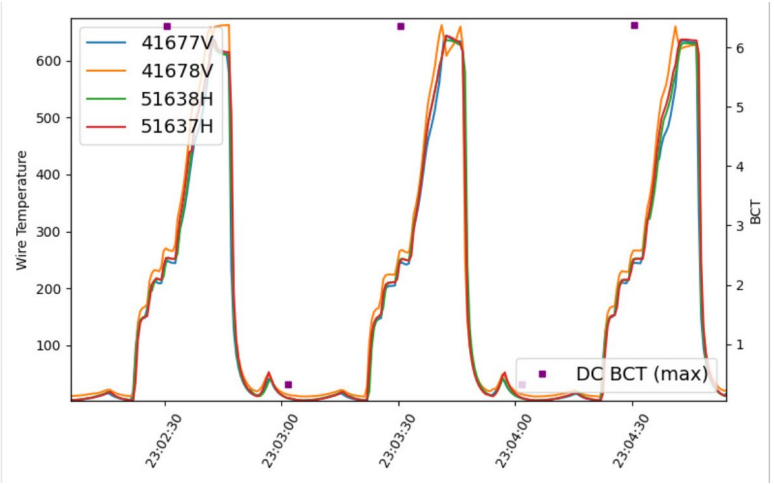
Parameters	**Values**
Beam σ_x	0.5947 mm
Beam σ_y	0.4122 mm
Revolution time τ	2.3×10^{-5} s
protons in beam	2.16×10^{13}
Scan direction	Horizontal

Next

- Benchmark Linac4 simulations done in the past (160MeV)
- Try to simulate SPS BWS RF heating (input power from MME/ABT to COMSOL, compare to continuous T measurements we have in place)
- ....
- Define other ‘use’ cases to simulate
    - LHC beam halo
    - Any PSI case ?
    - CNTs at SPS or LHC ?

SPS BWS RF heating (as meas last week)





L4 cases (B.Cheymol xxx years ago)

	$I = 70mA, t$ =400 μs		$I = 40mA, t = 400\ \mu s$		$I = 70mA, t = 100\ \mu s$	
E [MeV]	carbon	tungsten	carbon	tungsten	carbon	tungsten
50	3944	10390	2518	6350	1430	3100
57	3619	9500	2331	5842	1346	2880
79	2946	7900	1943	4768	1165	2410
86	2800	7490	1859	4527	1124	2303
100	2567	6806	1723	4136	1060	2131
115	2376	6242	1612	3814	1005	1990
129	2235	5822	1528	3574	964	1884
145	2105	5435	1328	3352	926	1786
160	2006	5136	1393	3182	897	1710

Table 4.10: Maximum temperature in Kelvin for a 33 μm carbon wire and a 40 μm tungsten wire, when the wire stays at beam core from 10 LINAC4 pulses and with 1 $mm \times 2\ mm$ beam.

	$I = 70mA, t = 400\ \mu s$		$I = 40mA, t = 400\ \mu s$		$I = 70mA, t = 100\ \mu s$	
E [MeV]	carbon	tungsten	carbon	tungsten	carbon	tungsten
50	4215	10868	2781	6550	1672	3300
57	3887	9990	2591	6042	1581	3078
79	3212	8110	2198	4968	1390	2605
86	3065	7692	2120	4728	1347	2500
100	2830	7007	1972	4336	1277	2326
115	2636	6443	1857	4014	1218	2184
129	2493	6023	1772	3773	1173	2077
145	2362	5635	1693	3552	1131	1978
160	2261	5337	1631	3380	1098	1902

Table 4.11: Maximum temperature in Kelvin for a 100 μm carbon and tungsten wire, when the wire stays at beam core from 10 LINAC4 pulses and with 1 $mm \times 2\ mm$ beam.