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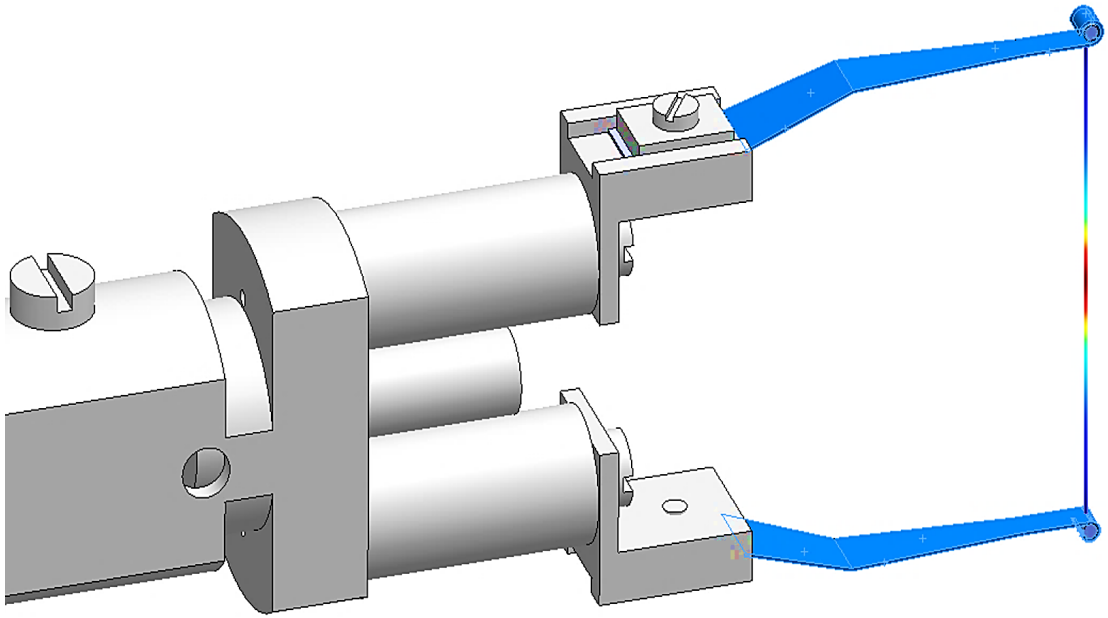
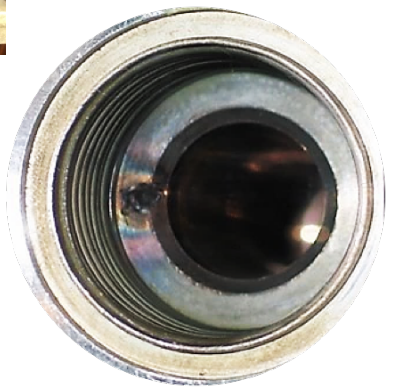
Thermal loads of wire-based instrumentation at ion linacs



Common targets in particle accelerators

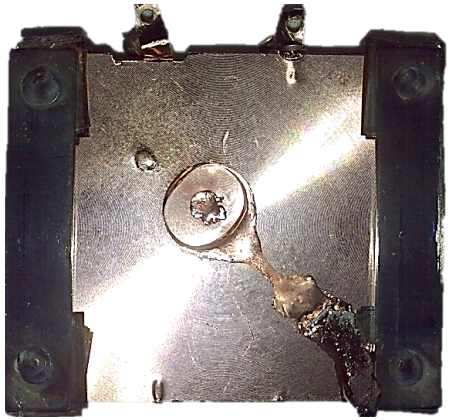
Beam shaping and transportation

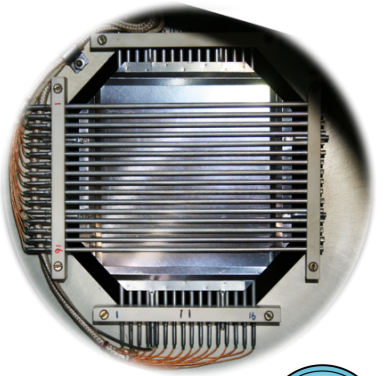
- Collimators and choppers
- Beam pipes and windows
- Research targets and beam dumps



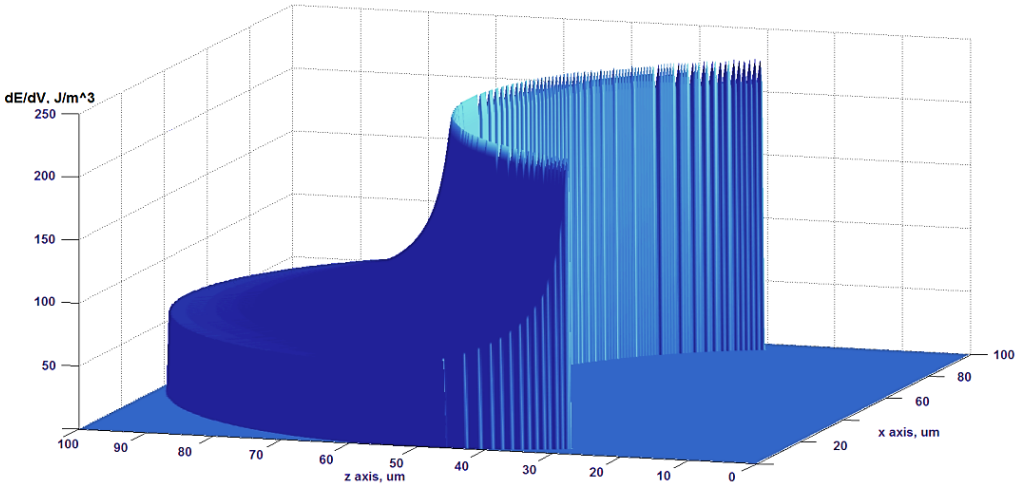
Diagnostics

- Faraday's cups
- Scintillation screens
- Wire monitors



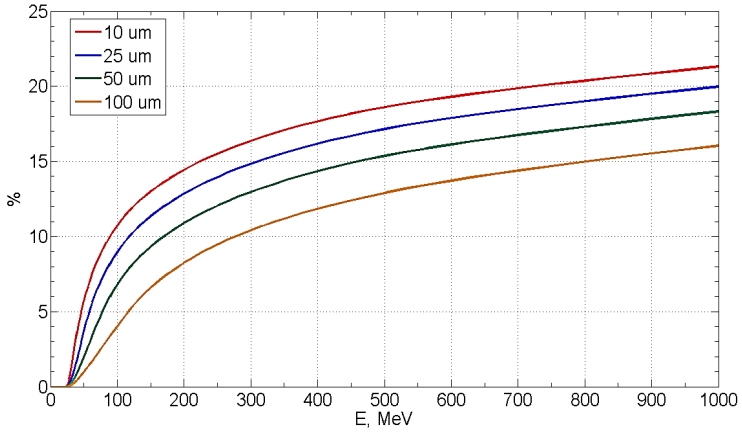


Secondary electron emission



δ-electrons

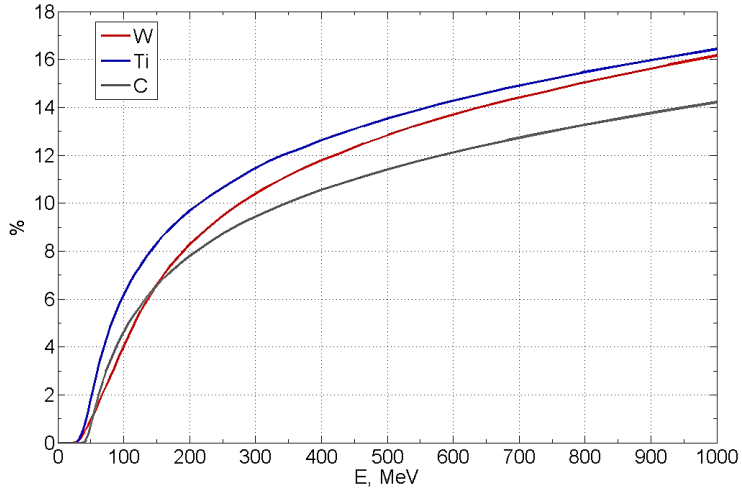
$$\frac{d^2N}{dTdx} = \frac{1}{2}Kz^2\rho\frac{Z}{A}\frac{1}{\beta^2}\frac{F(T)}{T^2}$$



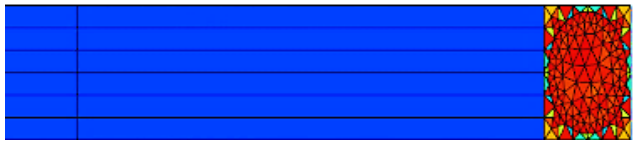
Low-energy secondary electrons

$$SEY = 0.01L_S\frac{dE}{dx}|_{el}\left[1+\frac{1}{1+E\cdot 5.4\cdot 10^{-6}/A_p}\right]$$

$$L_S = (3.68\cdot 10^{-17}NZ^{1/3})^{-1}$$

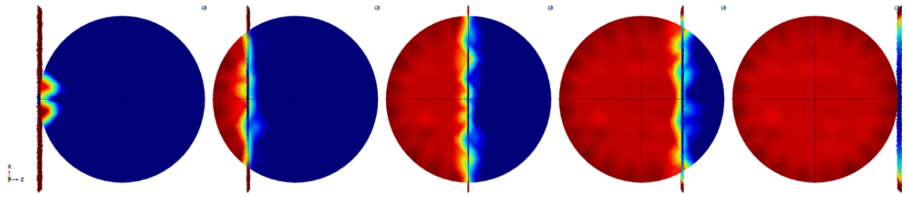


Comsol Multiphysics modeling

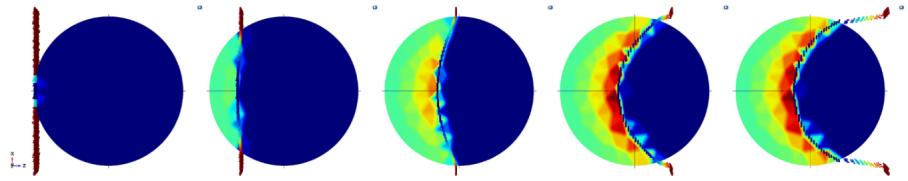


Particle-matter interactions

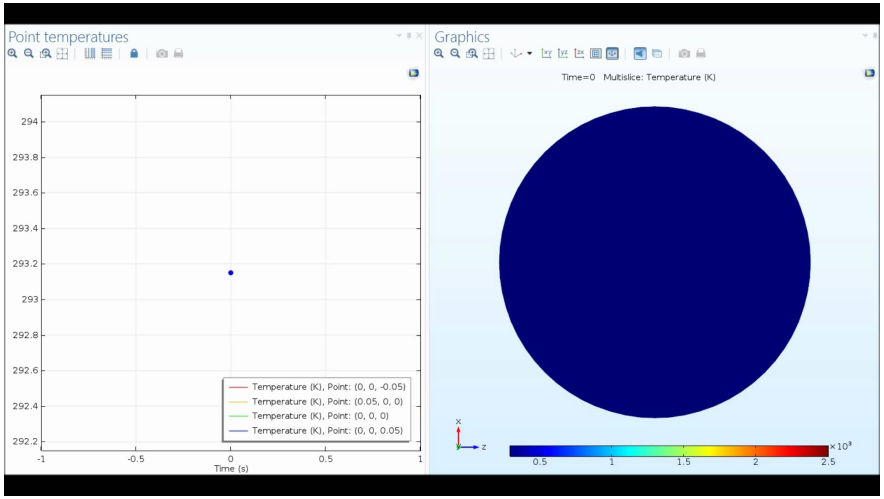
90 MeV protons



3.6 MeV protons



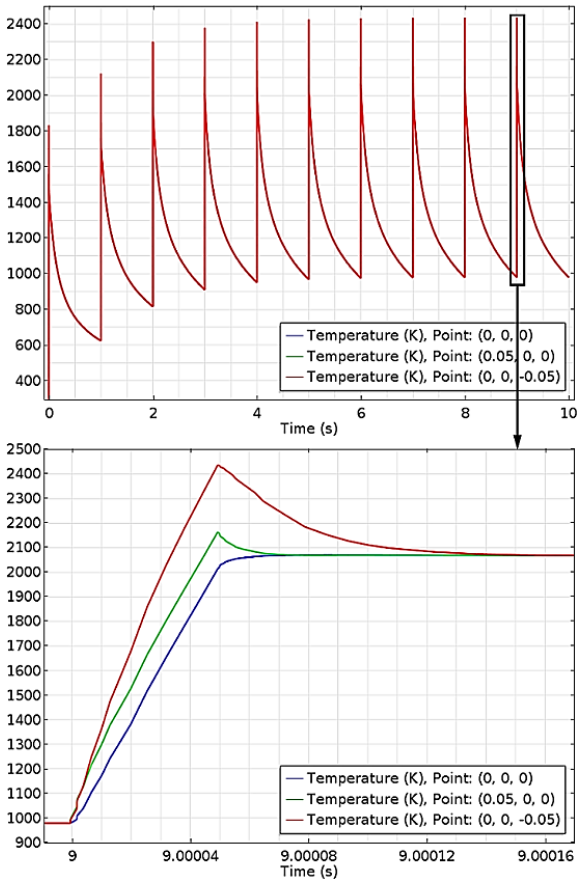
Thermal processes



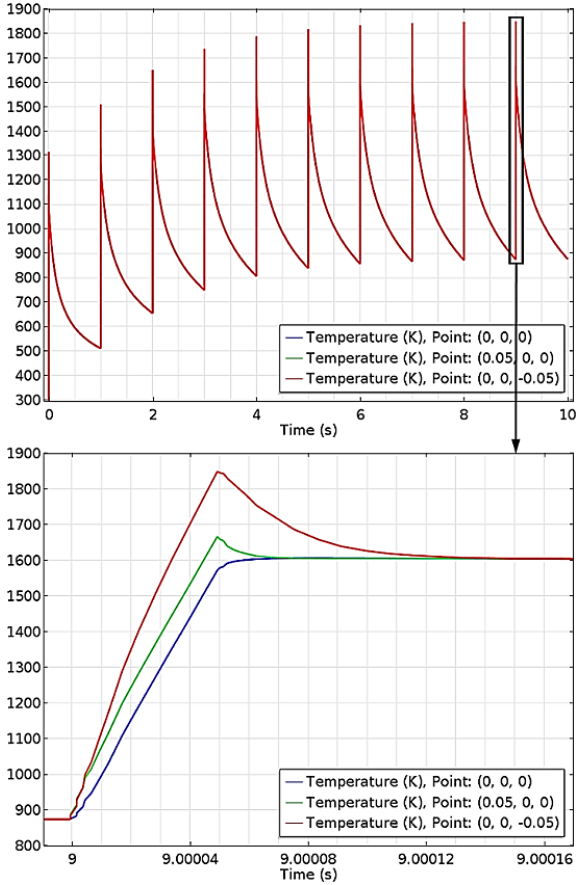
Wire target of BSM-ESS

$$k = I_{pulse} \cdot \tau_{dur.} \Big/ \sigma_x \cdot \sigma_y$$

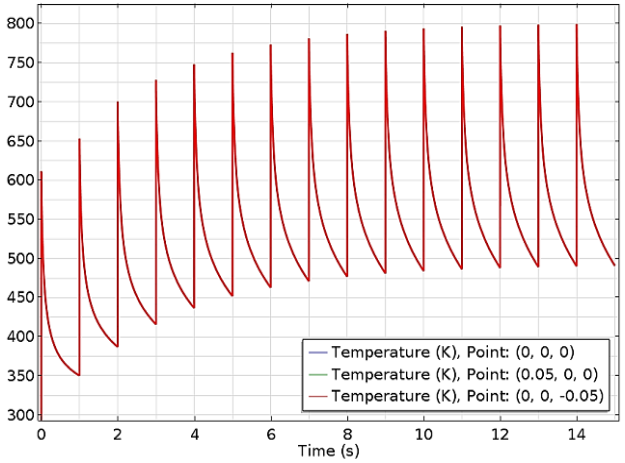
3.6 MeV, 62.5 mA



3.6 MeV, 40 mA



90 MeV, 62.5 мА

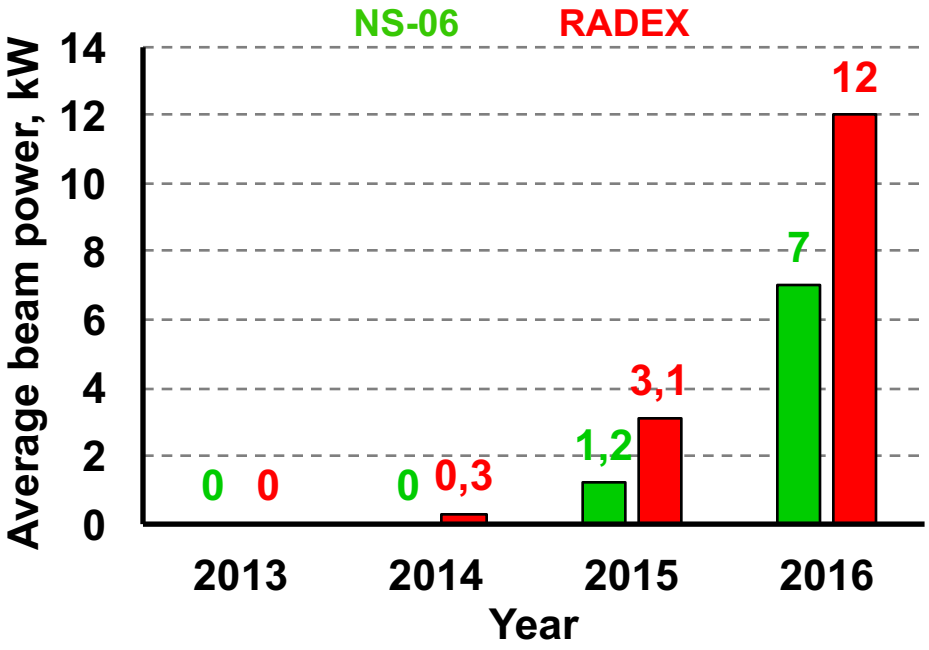


Signal/nose = 0.3

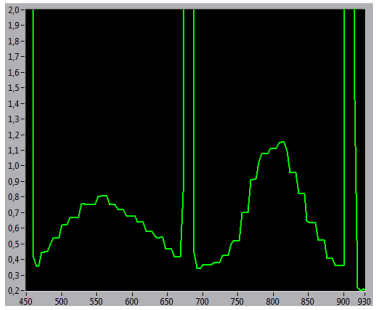
Signal/noise = 500

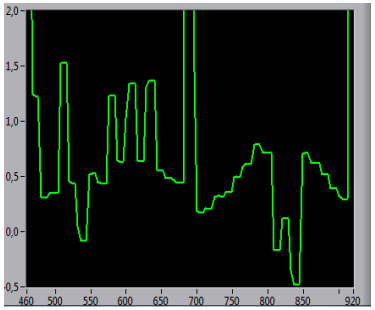
$$j = 120.4\, T^2 exp\left(-\frac{11\,600}{T}\varphi\right) \left[A/_{CM^2}\right]$$

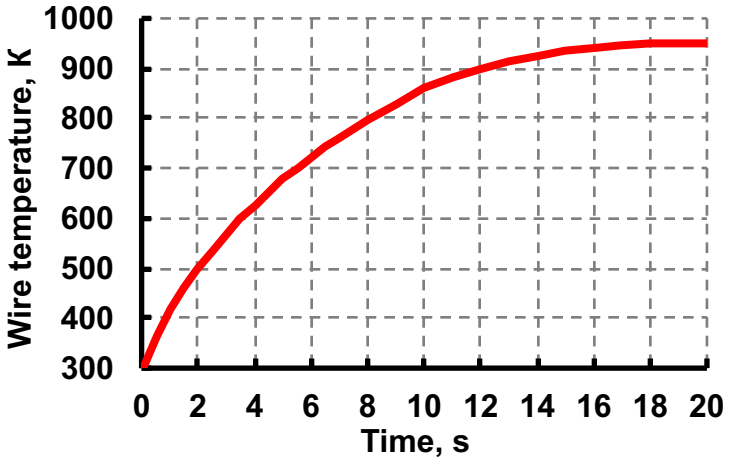
Multi-wire grids at LINAC INR



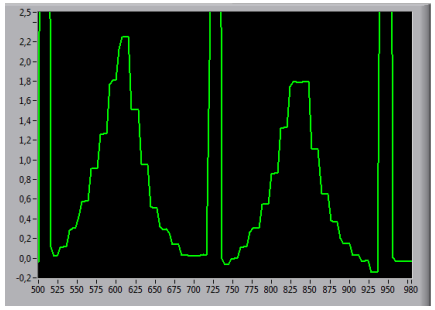
NS-06

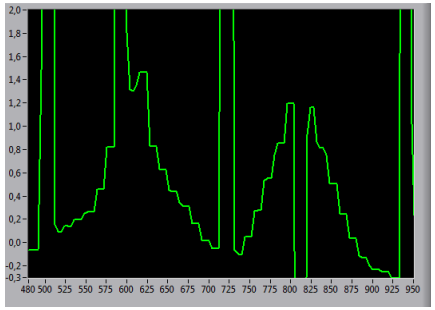




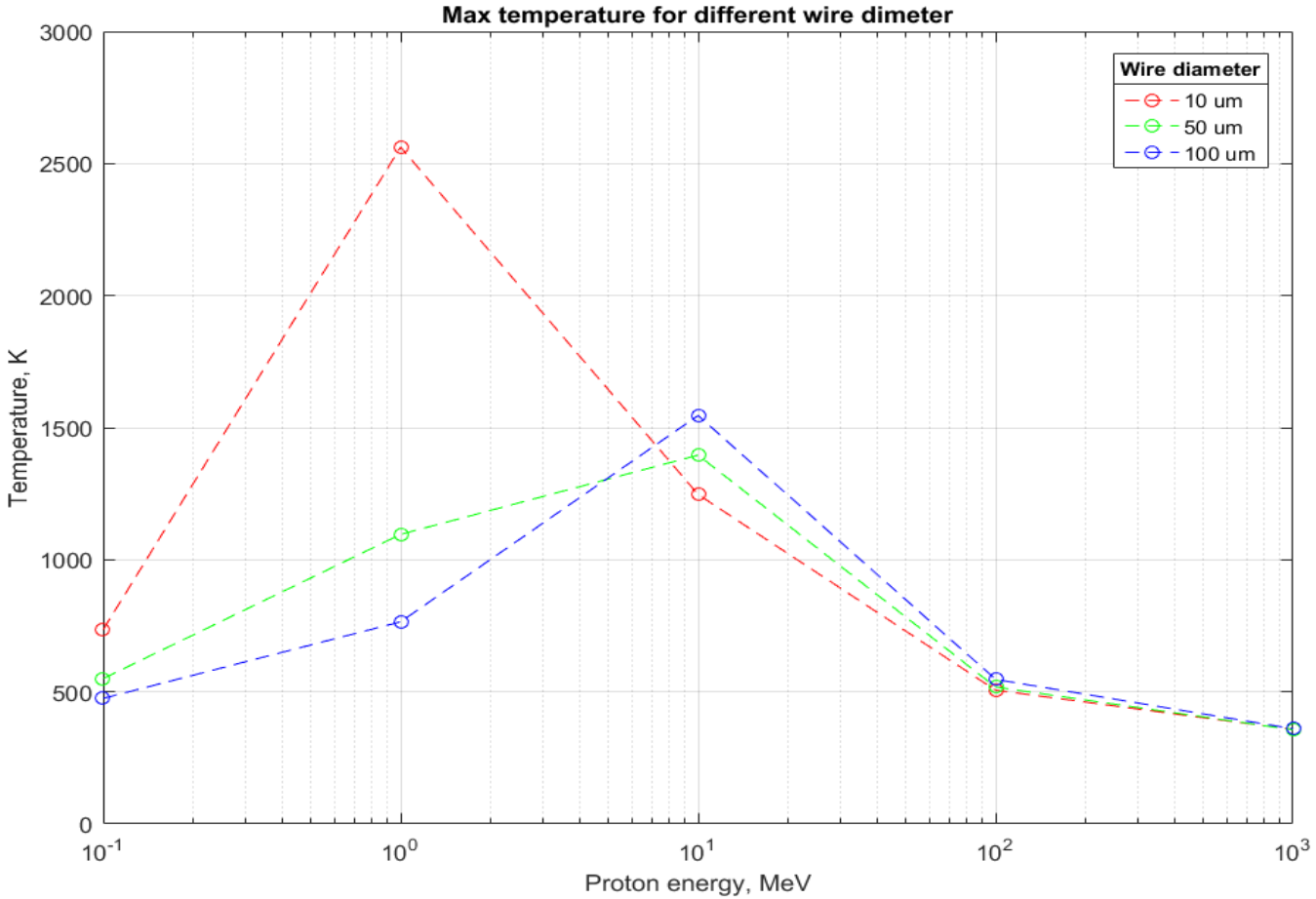


RADEX

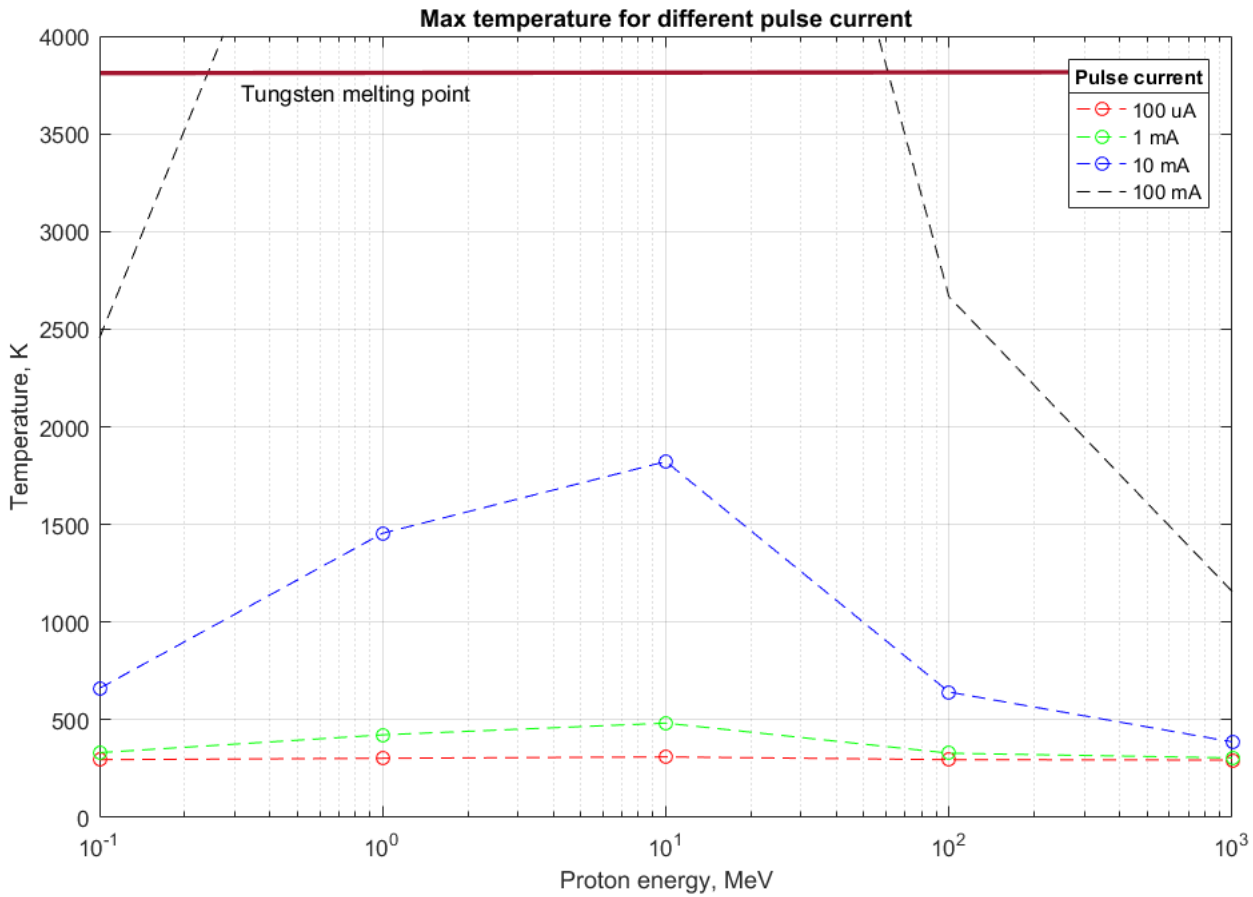




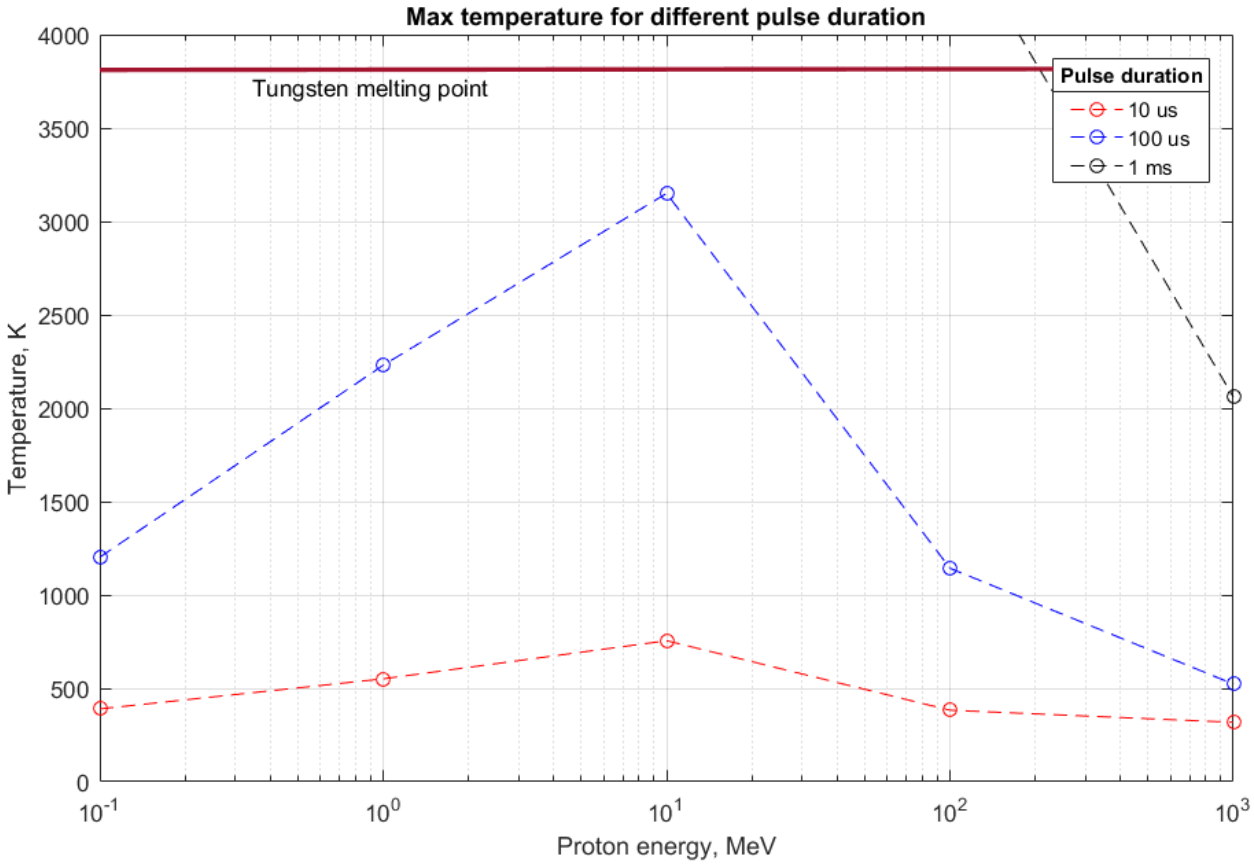
Results


Max temperature for different wire dimeter
Wire diameter
10 um
50 um
100 um
Temperature, K
Proton energy, MeV
3000
2500
2000
1500
1000
500
0
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}

Results


Max temperature for different pulse current
Tungsten melting point
Pulse current
100 uA
1 mA
10 mA
100 mA
Temperature, K
Proton energy, MeV
4000
3500
3000
2500
2000
1500
1000
500
0
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}

Results


Max temperature for different pulse duration
Tungsten melting point
Pulse duration
10 us
100 us
1 ms
Temperature, K
Proton energy, MeV
4000
3500
3000
2500
2000
1500
1000
500
0
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}