Update on Temperature Calculations with Mathematica

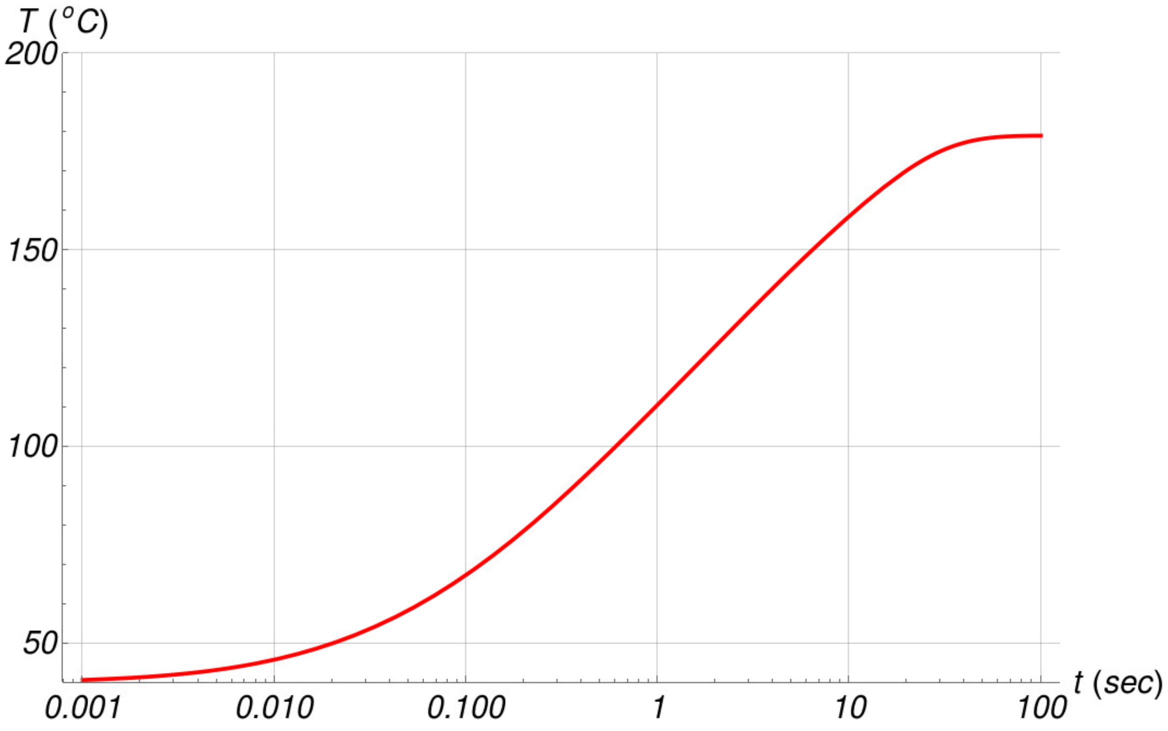
Hovanes Egiyan

Overview

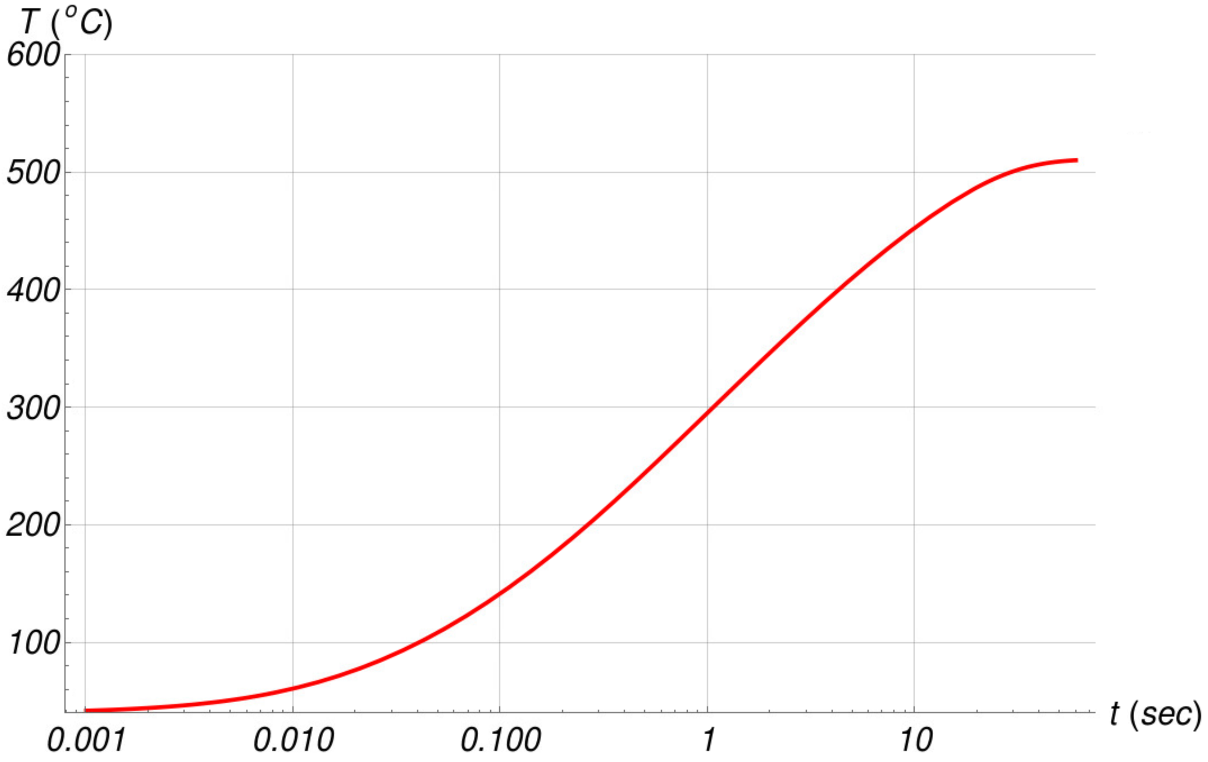
- Solved time-dependent Poisson equation for KLCPS64 nominal and x-angled models to determine how fast the hot spot develops.
  - The answer is that it happens very fast, on the order of ~1 second from the moment the beam is established.
    - No large changes within 10 ms is expected
  - We will need to use the accelerators FSD system to turn off the beam when a condition leading to "elevated" temperatures is encountered.
- Looked at some of the FLUKA simulations by Vitaly
  - Vitaly provided the FLUKA output data files with cylindrical grid
  - Nominal beam, beam with FWHM=0.8mm, and horizontally α_{yaw}=0.5mrad angled beam are analyzed.
  - The beam channel model in Mathematica matches the upstream part of the channel description in FLUKA
    - The downstream part z > 240cm seems to be designed more for radiation level control
      - Little impact on temperature distribution
      - Not clear how the cooling would work near magnets with cooling channels at (x,y)=(±5,±7)cm positions.
  - Obtained maximum temperature is low for the nominal beam, only T_{max}≈95 ^{O}C.
    - With a narrow beam transverse profile T_{max}≈130 ^{O}C.
  - Considerably lower T_{max} than T_{max}≈250 ^{O}C from Vitaly's model in February.
    - Mathematica sees ~53KW power in the data file.
    - The discrepancy cannot be due to different cooling (I get T_{max}≈140 ^{O}C if I used only two cooling channels instead of four and only consider 60cm z-segment and 5cm x-section of the absorber)
    - There seems to be ~20% less power density per unit z-distance now that in February model.
  - The CPS absorber in the model seems to be surrounded by BLACKHOLE material that absorbs all particle.
    - Unlikely to impact the power distribution
    - Makes radiation level estimations unrealistic.

Time dependence of the temperature

Transition from uniform 40 ^{O}C to nominal beam. Hot spot temperature versus time is plotted.



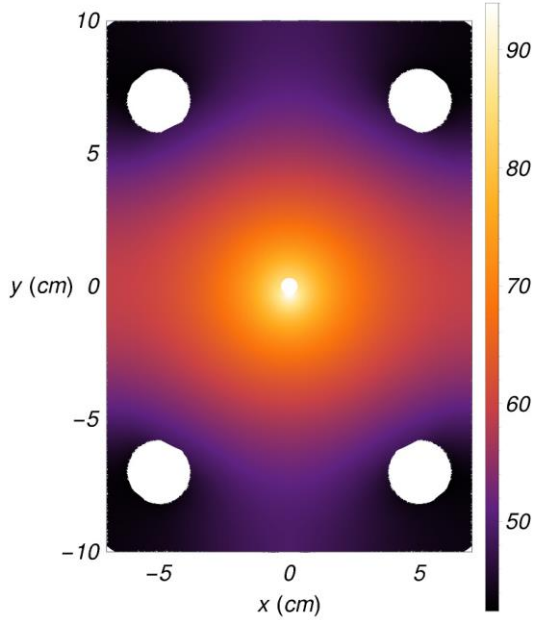
Transition from uniform 40 ^{O}C to 1mrad horizontally shifted beam. Hot spot temperature versus time is plotted.

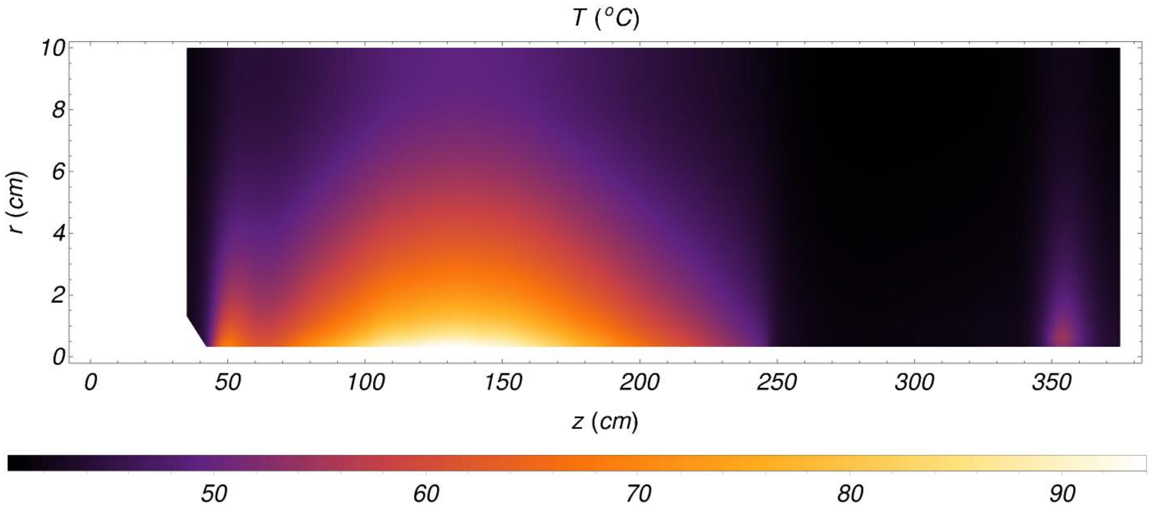


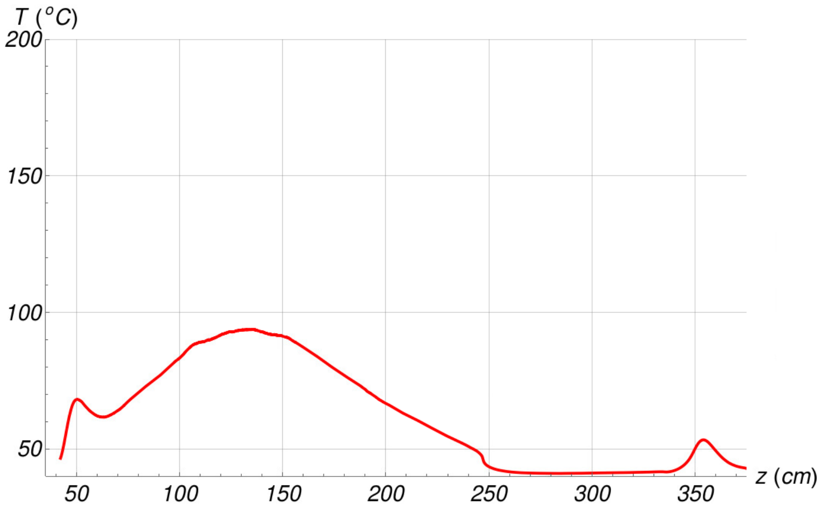
- About one half of the change in temperature occurs within a time period on the order of 1 second. After that, the temperature slowly reaches the thermal equilibrium temperature in about ~30 seconds.
- We will need to turn the beam off faster than one seconds to avoid temperature-related problems.
  - We need to setup FSD signals for conditions that can produce elevated temperatures.

Comparison with FWHM=0.8mm ($\sigma_b \approx 1/3$mm) beam

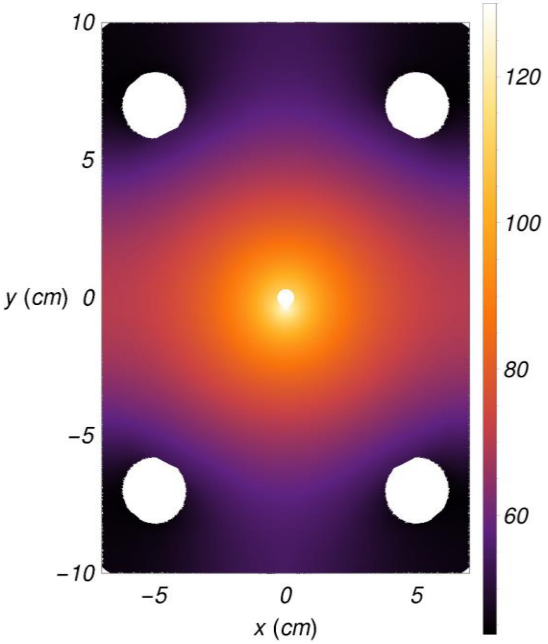
Nominal configuration

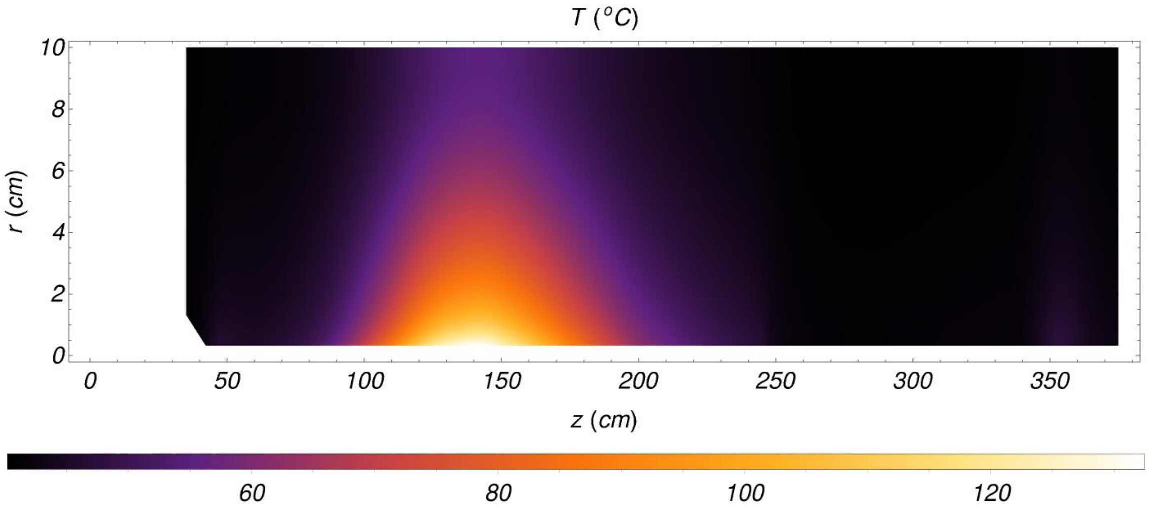


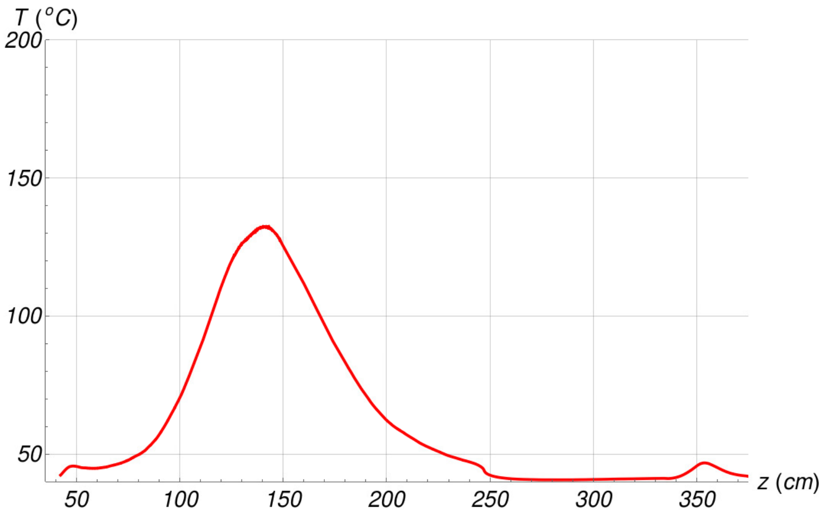




Configuration being tested

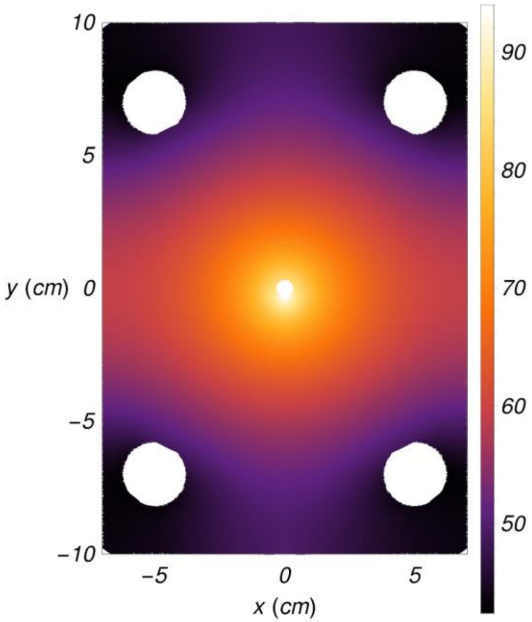


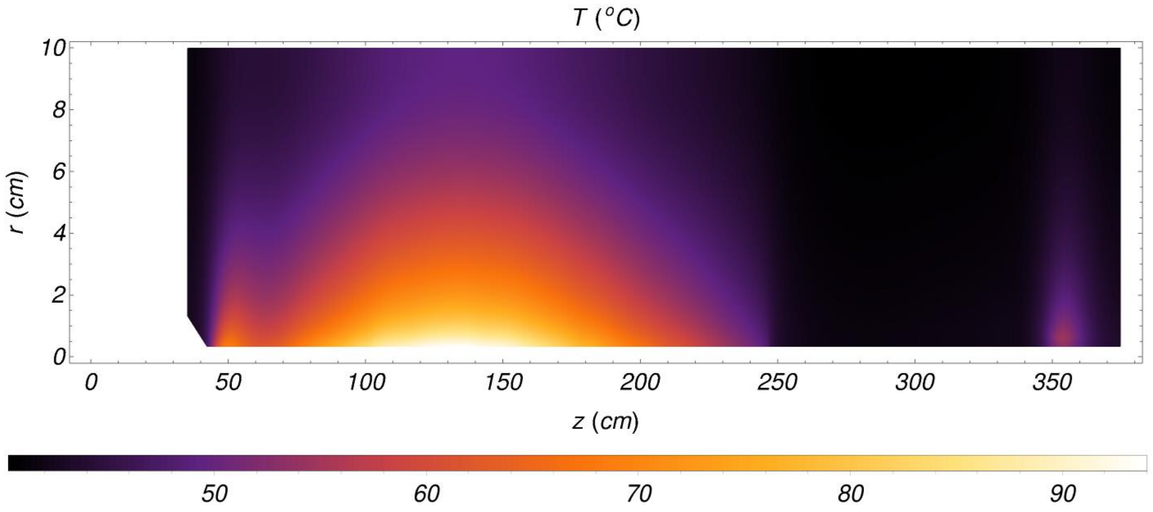


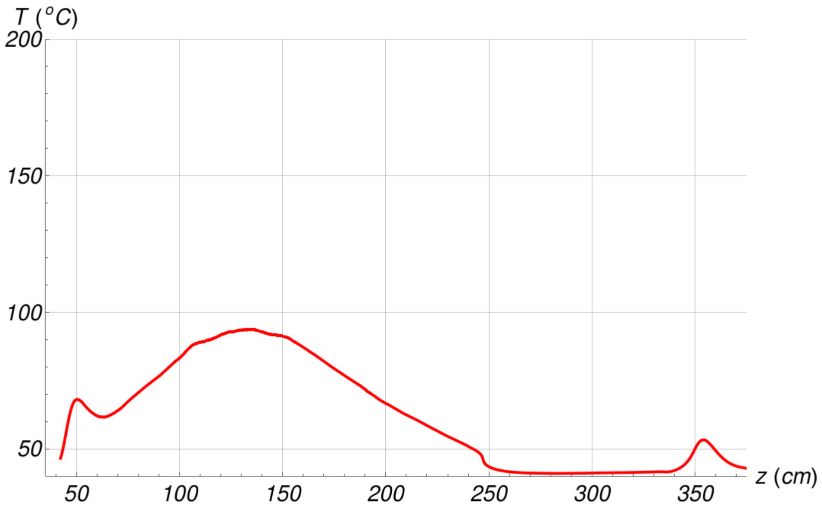


Comparison with α_{yaw}=0.5mrad horizontally angled beam

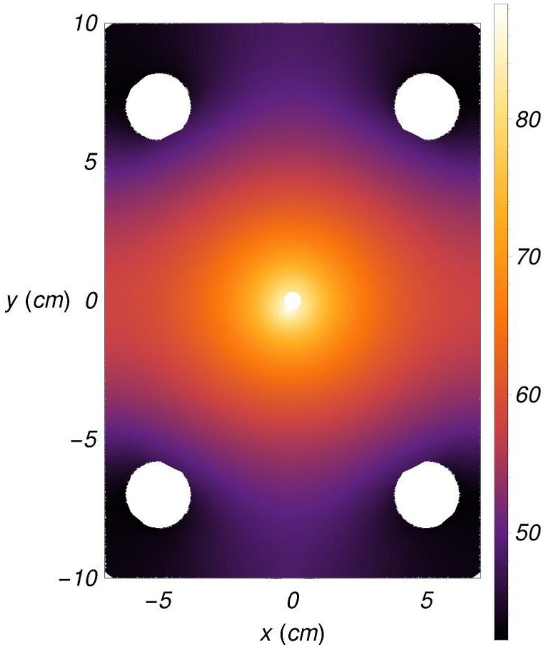
Nominal configuration

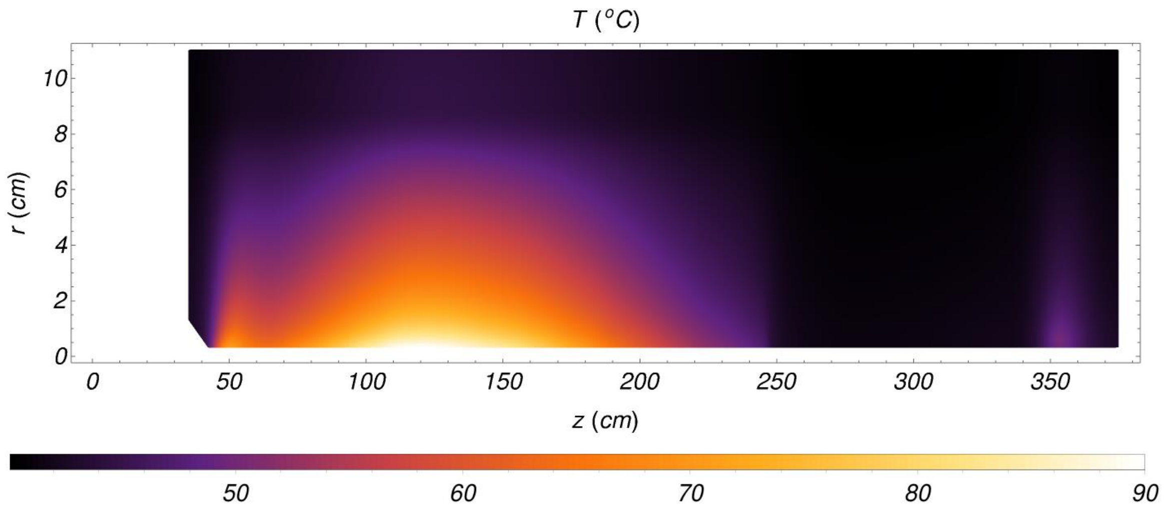


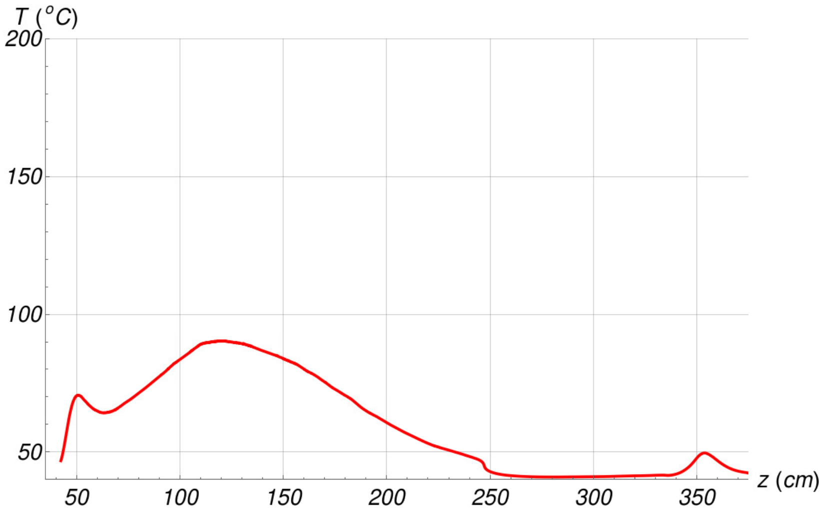




Configuration being tested







Summary and Outlook

- Time dependence of the hot-spot temperature has been investigated for KLCPS64 model
  - Need to setup FSD-s to protected against conditions that may cause "high" temperatures.
- So far analyzed three configurations from Vitaly
  - Look good , but I do not understand why there is ~100 ^{O}C difference in T_{max} between current model and February model.
- Need to look at the rest of Vitaly's configurations.
  - We need also rectangular grid data from Vitaly to try to check the results for the nominal setup to understand if this low T_{max} is real.
    - Tim can run ANSYS on it too.
    - It could be much shorted in Z.
- Need to analyze Pavel's KLCPS69 model studies.