Temperature Calculations with Mathematica

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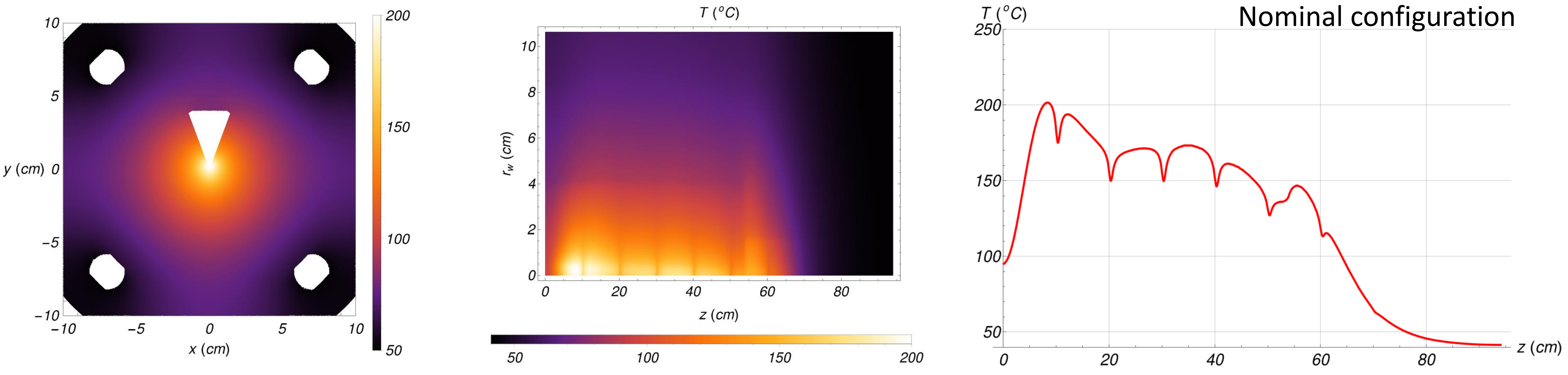
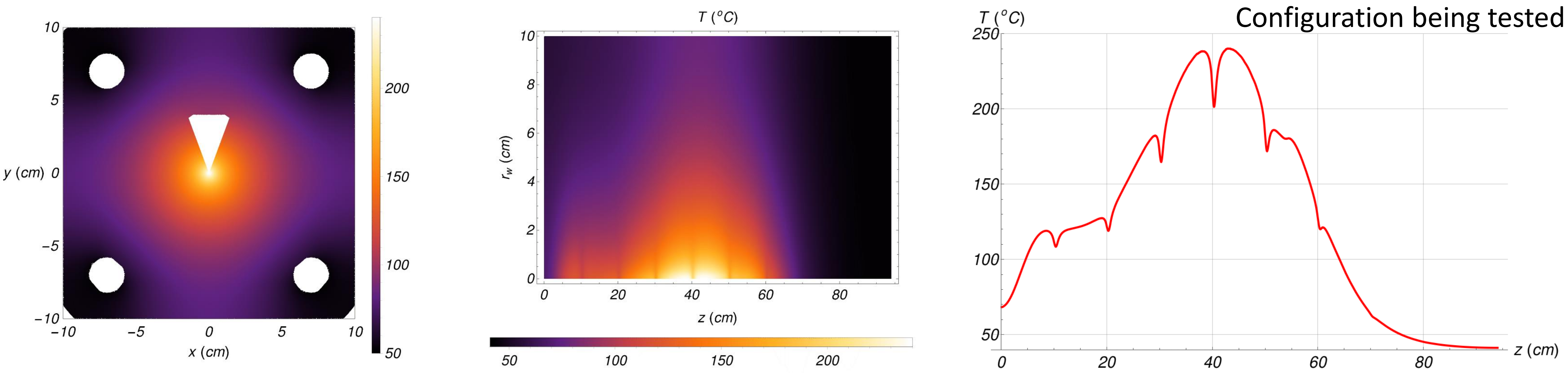
Pavel’s Tests

- During the last meeting Pavel presented test FLUKA runs to simulate CPS response for different beam conditions
- I looked at all the tests that Pavel did with KLCPS64 and KLCPS65 model to estimate the temperature in the absorber.
    - Fixed the fake x-asymmetry in the cylindrical coordinates.
- I used water temperature T_{water}=40 ^{o}C with cooling holes offset at 7cm in each direction for these thermal analysis of these tests.
- One of the tests produces high temperatures in the absorber than needs to looked at more carefully
    - Horizontal angle (and probably horizontal shifts ~ 2mm) causes relatively higher temperatures
    - I checked this with both rectangular and cylindrical grids.
    - Analysis of data with the rectangular grid from FLUKA shows lower temperature: difference is more than 100 ^{0}C.
    - Tim confirmed the results with the rectangular grid for this configuration.
    - Rectangular grid in FLUKA may need to be finer to be able to resolve narrow hot spots near surfaces.

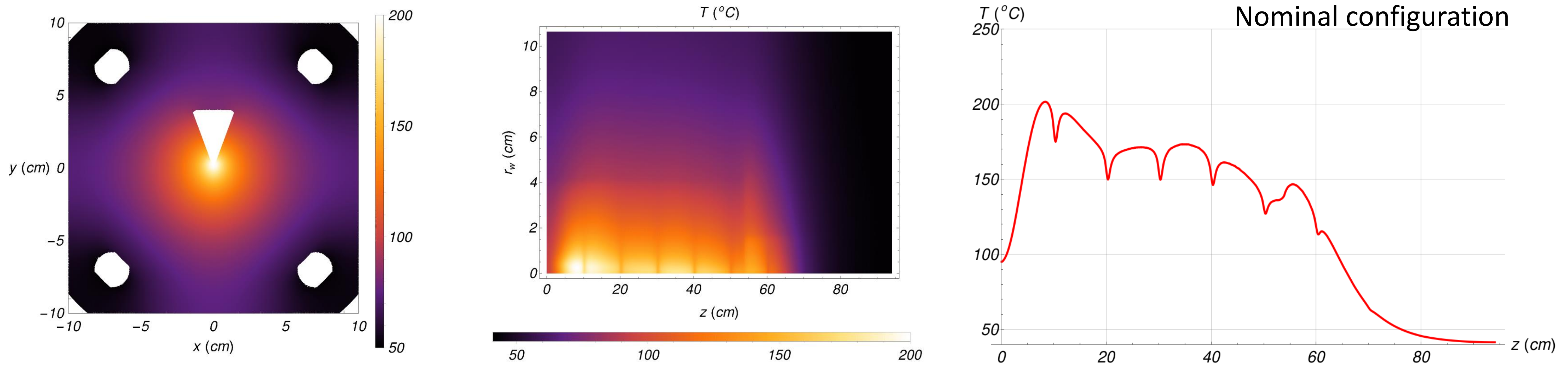
Test Configuration Name	Hot Spot Location Section	R_{max} (cm)	ϕ_{max} (deg)	Z_{max} (cm)	T_{max} (°C)	T_{cold} (°C)	Maximum power (KW/cm³)
All Nominal ($\sigma^{(x,y)}_{beam}$ = 1 mm, 4 holes)	Triangular	0.25	70 & 110	8	202 ±25	55	5
$\sigma^{(x,y)}_{beam}$ = 100 μm	Triangular	0.0	N/A	44	242 ±25	65	14
90% B-field	Rectangular	0.15	90	58.5	265 ±25	60	8
110% B-field	Triangular	0.15	66	8.5	320 ±25	70	6
-1mm shift in Y	Triangular	0.2	70	8	270 ±25	65	4.5
+1mm shift in Y	Rectangular	0.1	90	57	203 ±25	60	6.3
-1mrad angle in Y	Triangular	0.15	70	8	350 ±25	70	6.4
+1mrad angle in Y	Rectangular	0.15	90	59	285 ±25	65	9
+1mm shift in X	Triangular	0.35	70	7.5	345 ±25	70	6.5
+1mrad angle in X	Triangular	0.4	67	7.5	565 ±100	90	10.5
20% R.L. radiator	Triangular	0.1	70 &110	8	255 ±25	60	3.5
Nominal, no cooling holes	Triangular	0.25	70 & 110	8	190 ±25	55*	5
-1mrad in Y, no cooling holes	Triangular	0.1	70 & 110	8	330 ±25	70*	6.4
+1mrad angle in X, no cooling holes	Triangular	0.4	68	7.5	540 ±100	100*	10.5
Nominal, no holes, rectangular grid	Triangular	0.25*	70 & 110*	8	195 ±25	60*	5
-1mrad in Y, no holes, rectangular grid	Triangular	0.0*	N/A	8	343 ±25	85*	5.4
+1mrad in X, no holes, rectangular grid	Triangular	0.4*	67*	7.5	420 ±100	95*	10

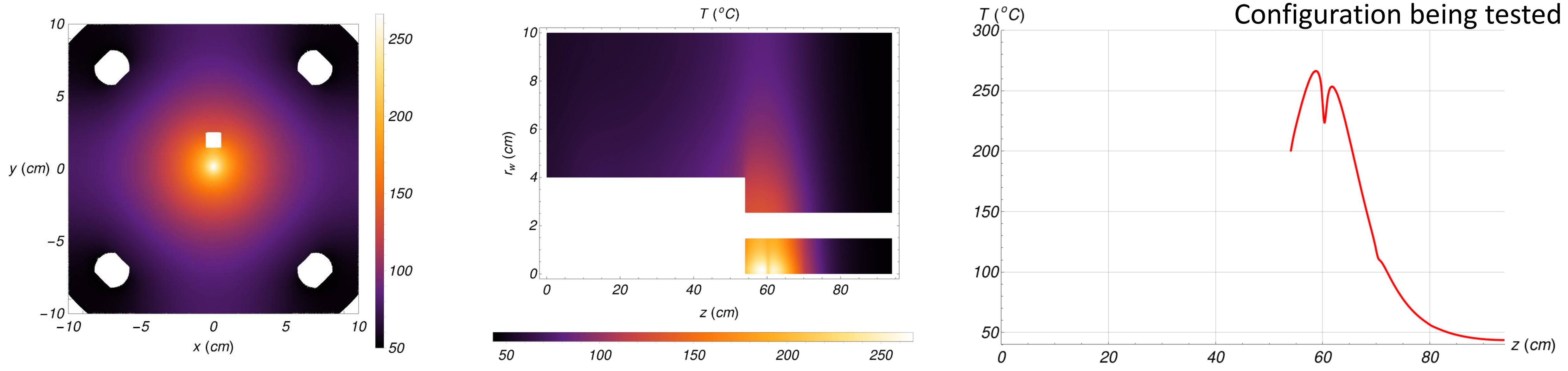
Comparison with 100μm beam



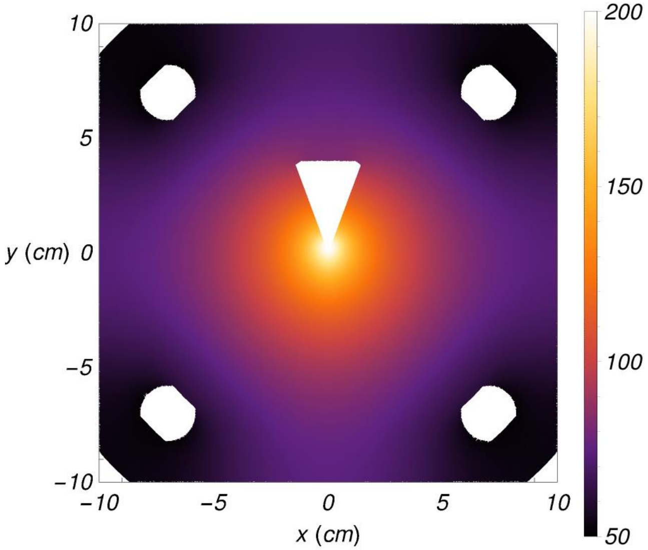


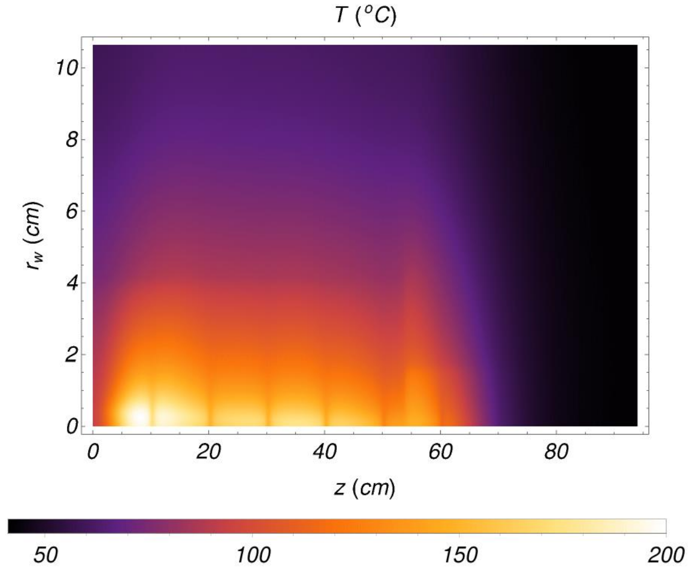
Comparison with 90% B-field



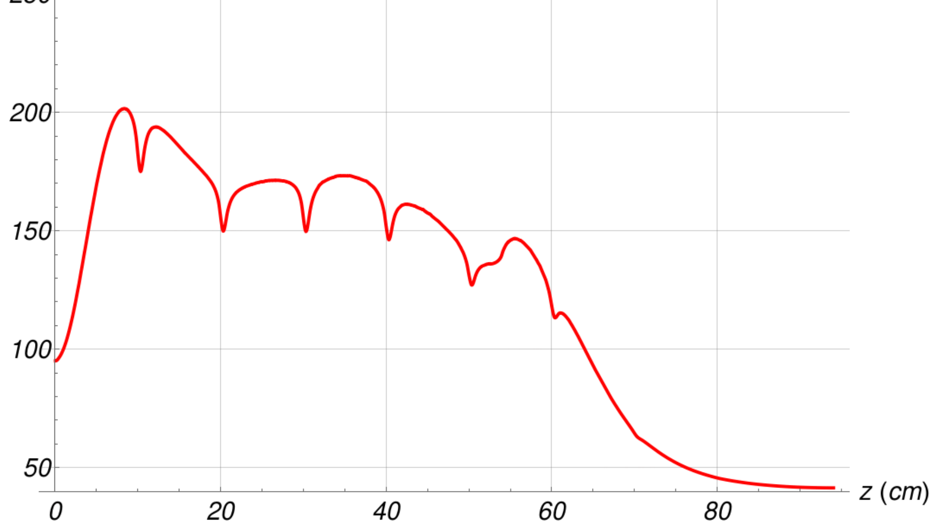


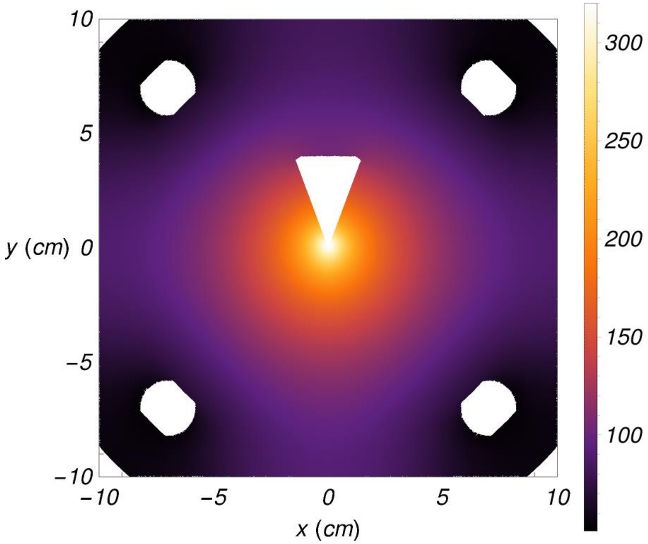
Comparison with 110% B-field

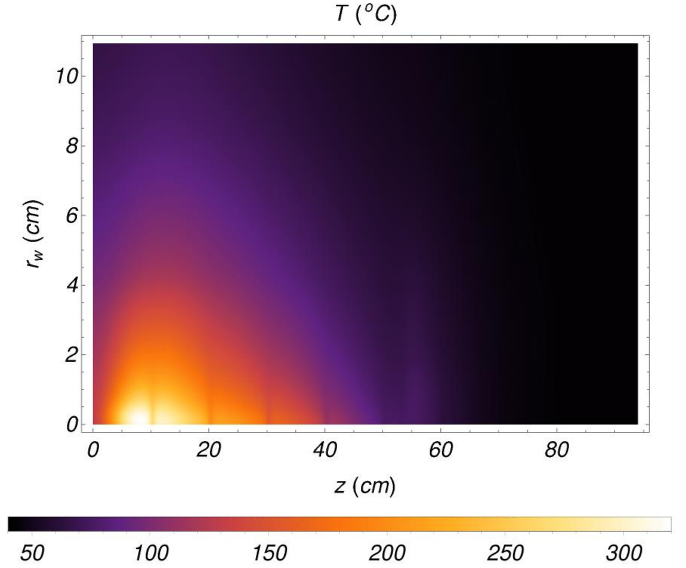




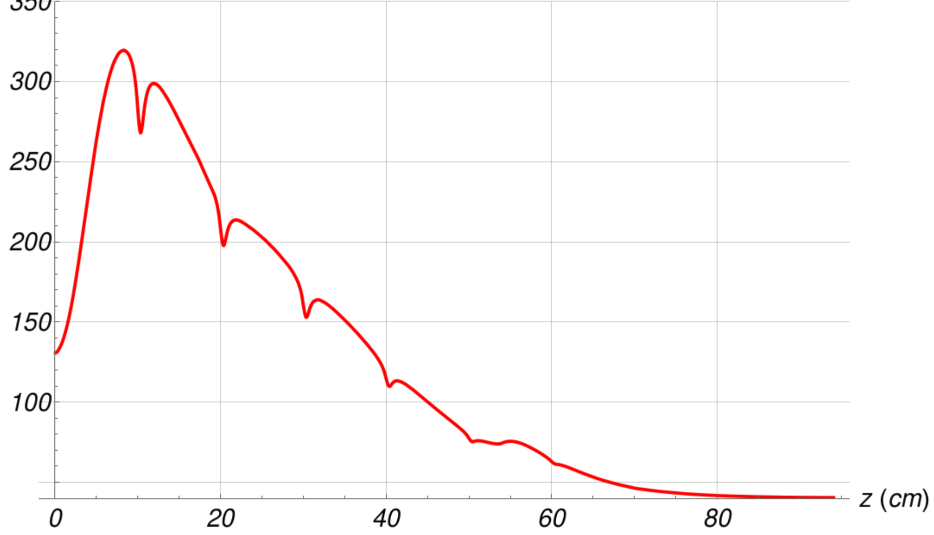
Nominal configuration





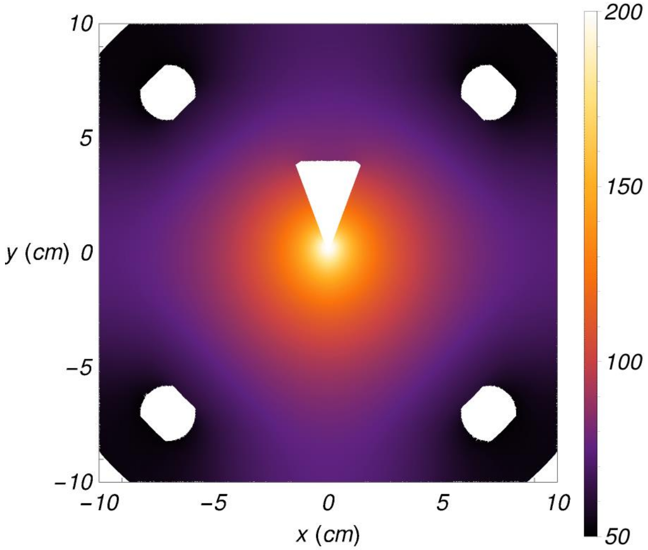


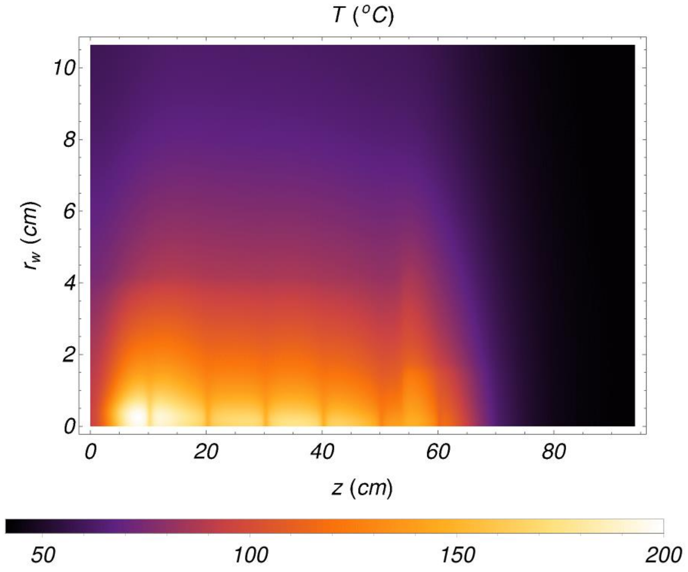
Configuration being tested

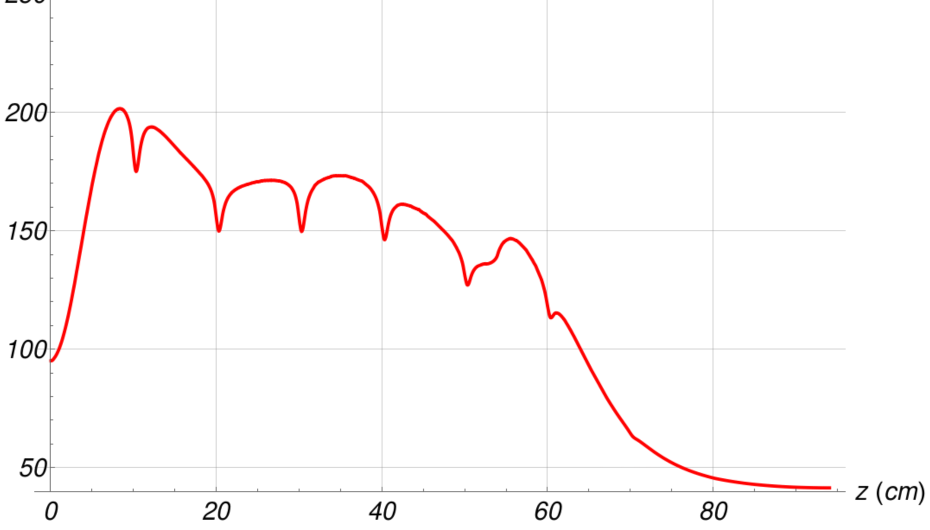


Comparison with beam shifted by +1mm in Y

Nominal configuration







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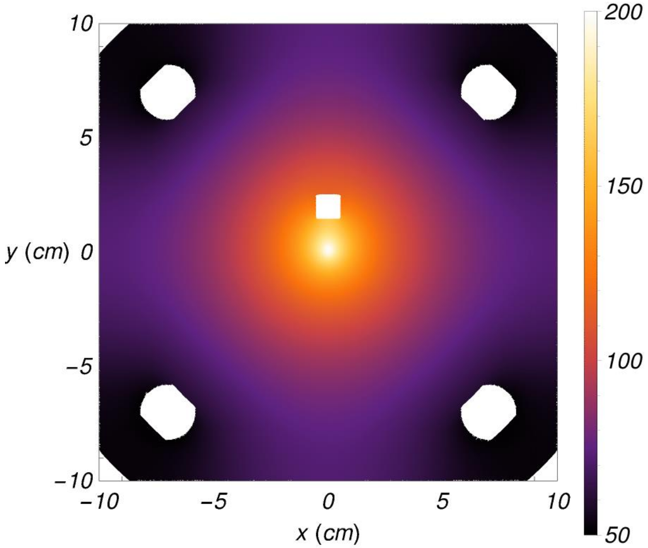
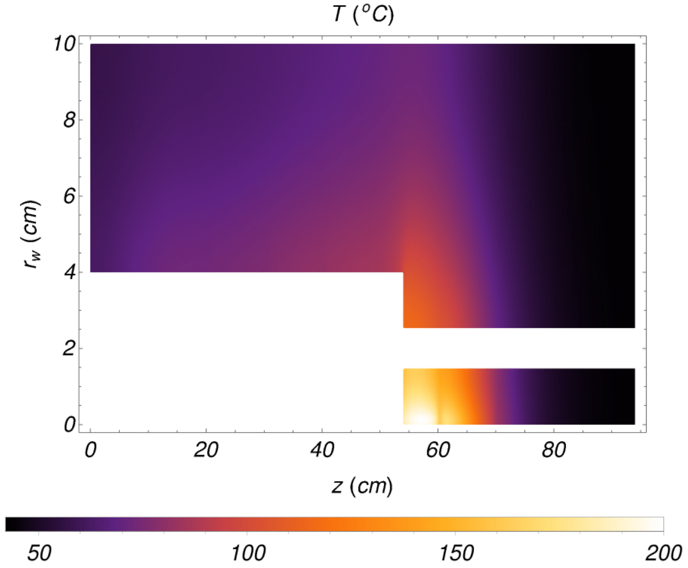
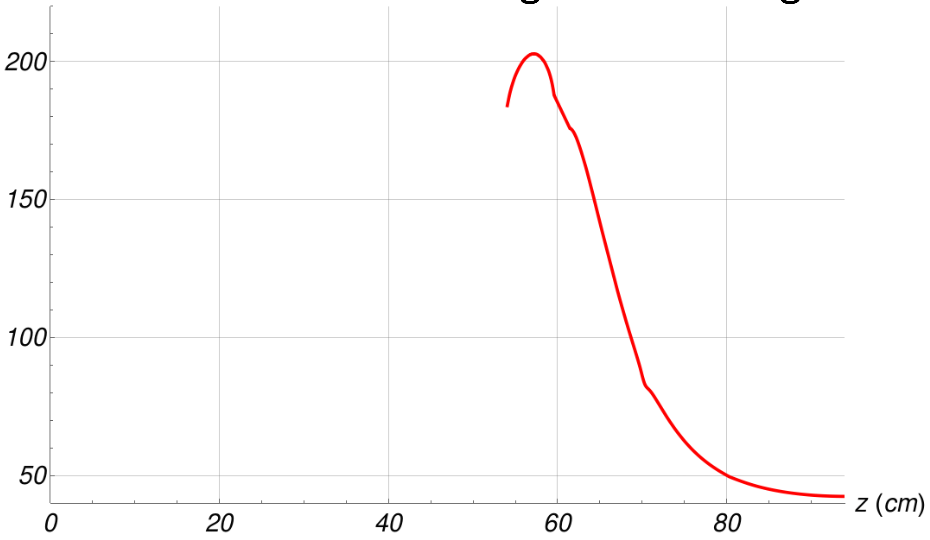
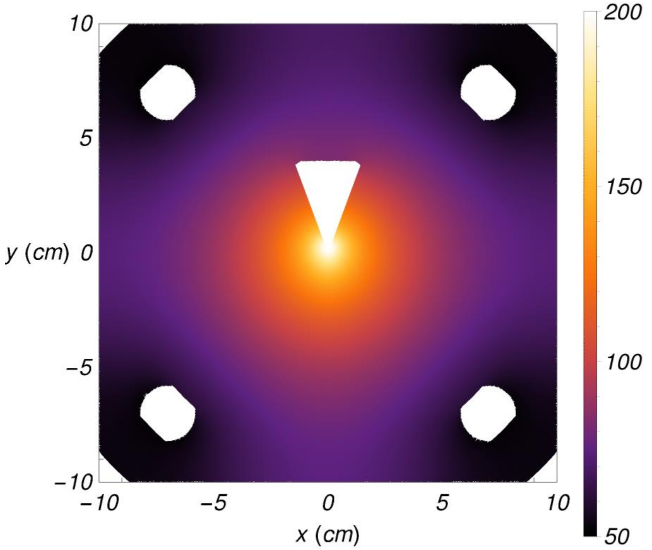
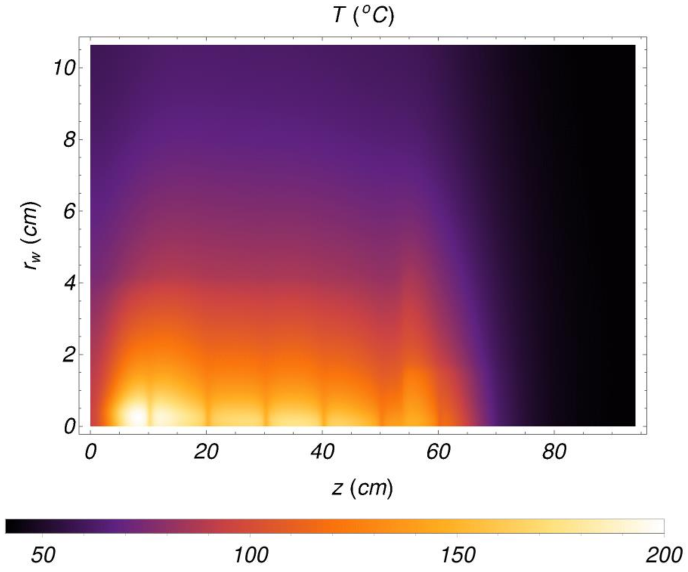




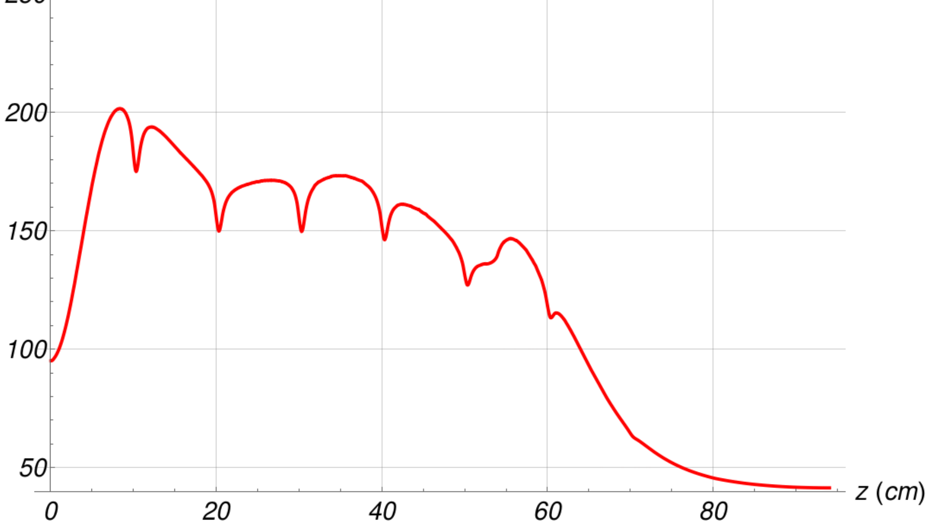


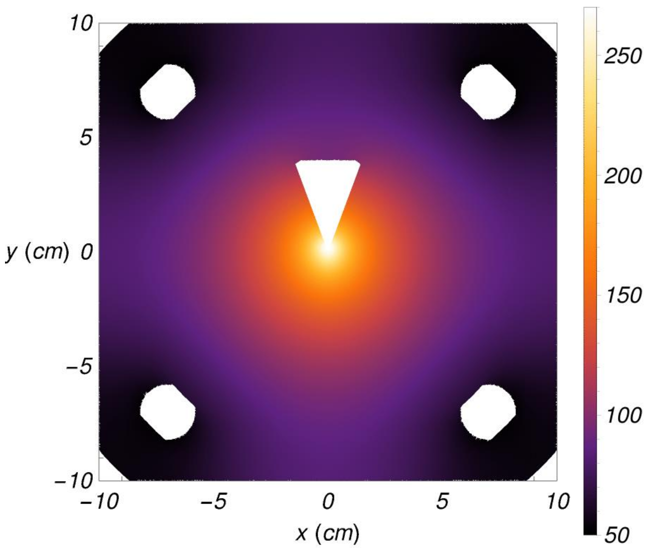
Comparison with beam shifted by -1mm in Y

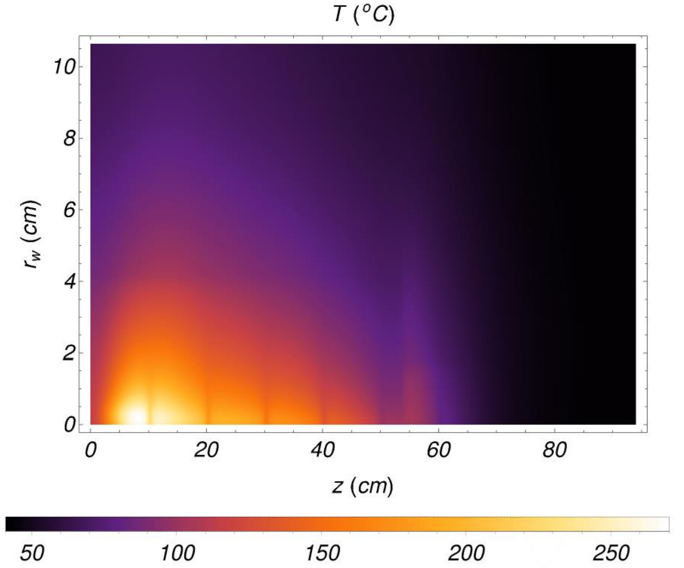




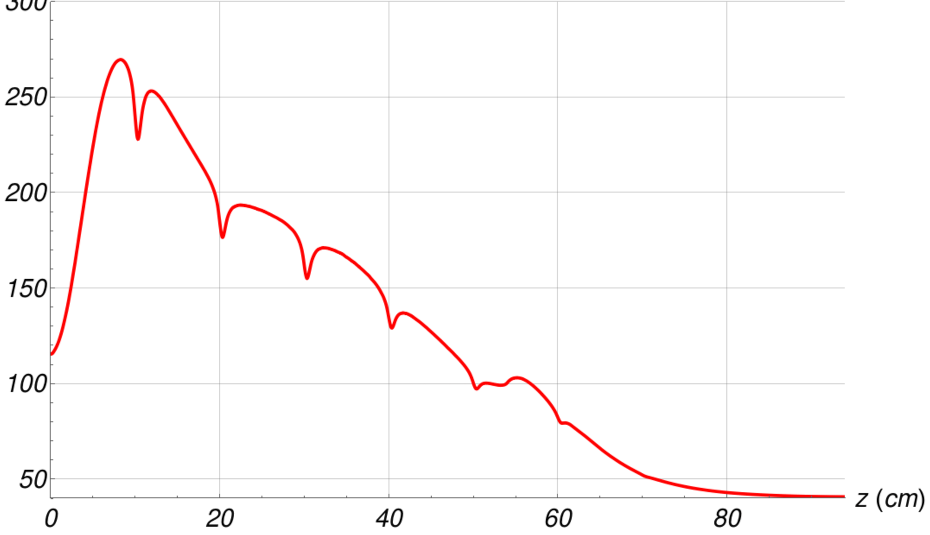
Nominal configuration





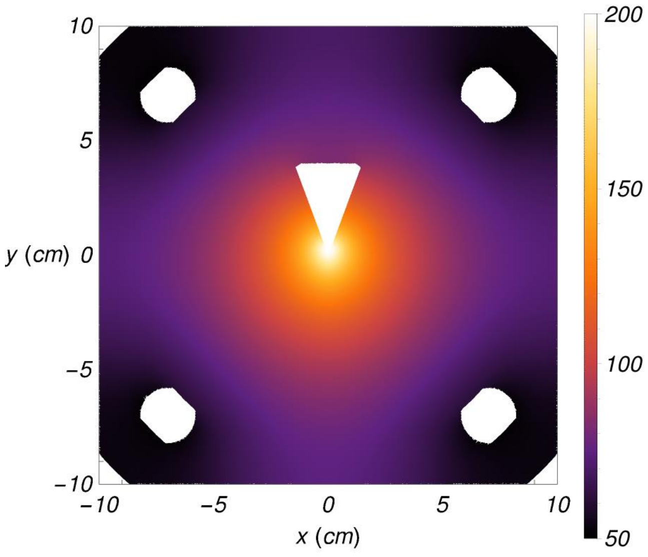


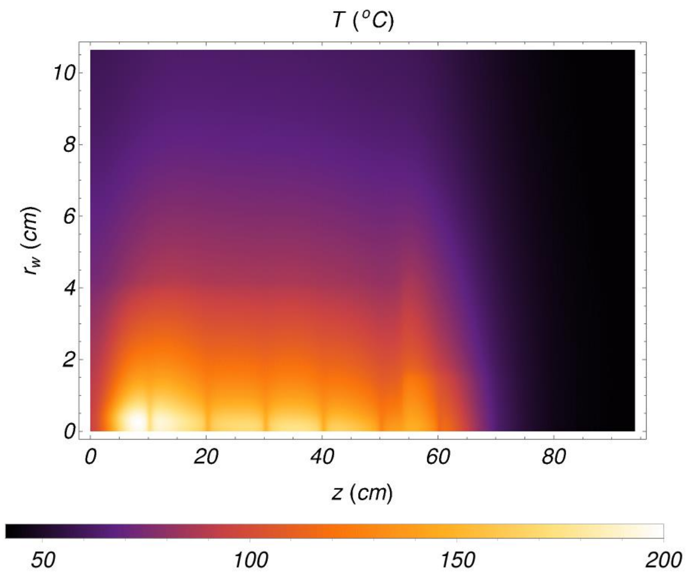
Configuration being tested

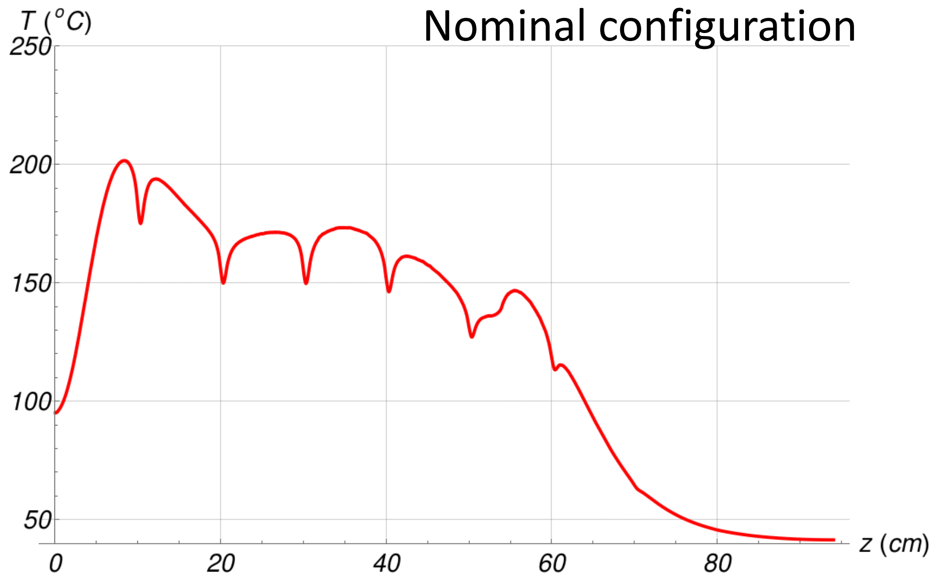


Comparison with beam angled by +1mrad in Y

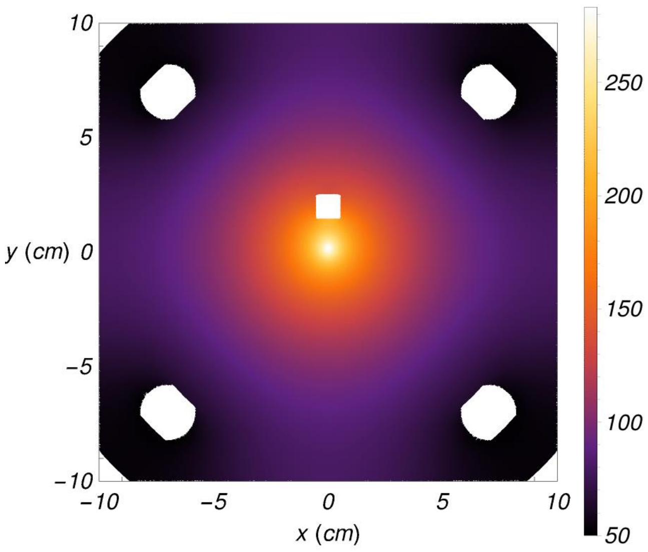
Nominal configuration

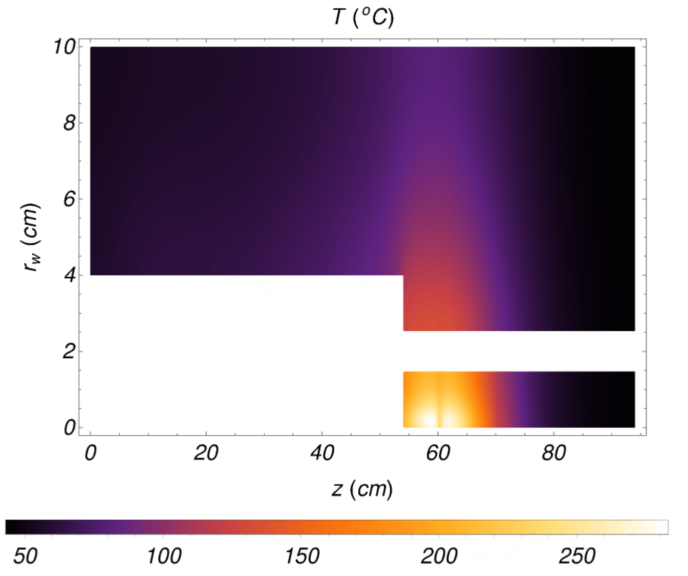


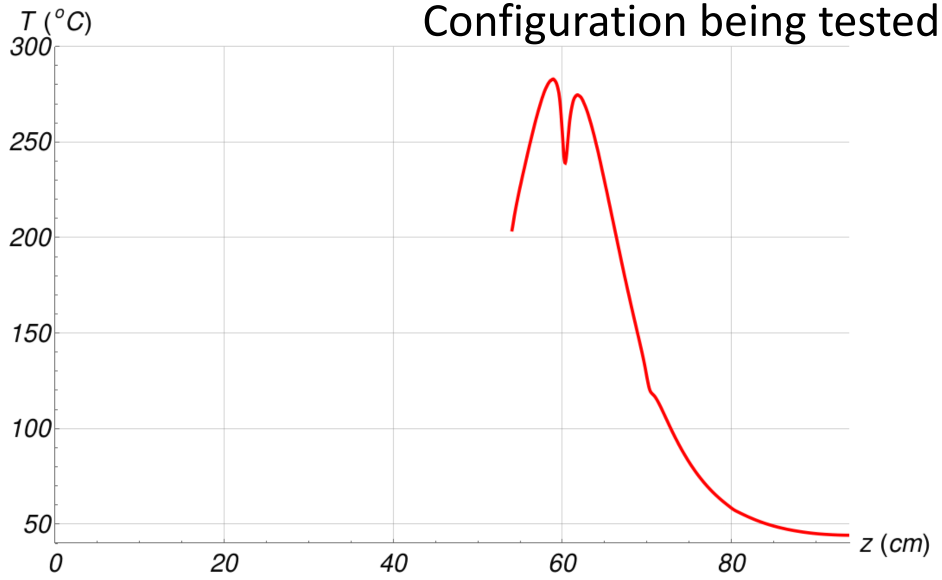




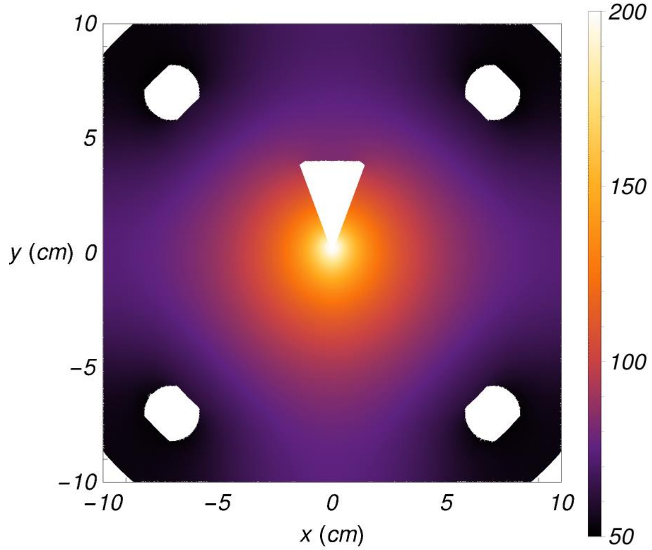
Configuration being tested

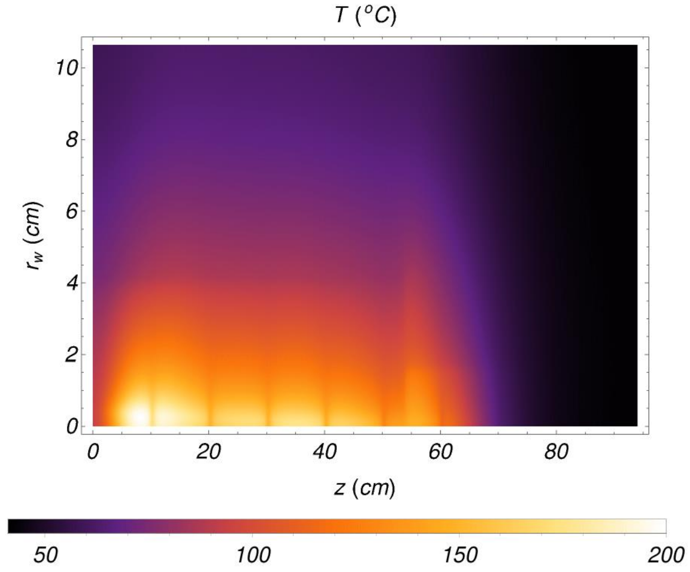


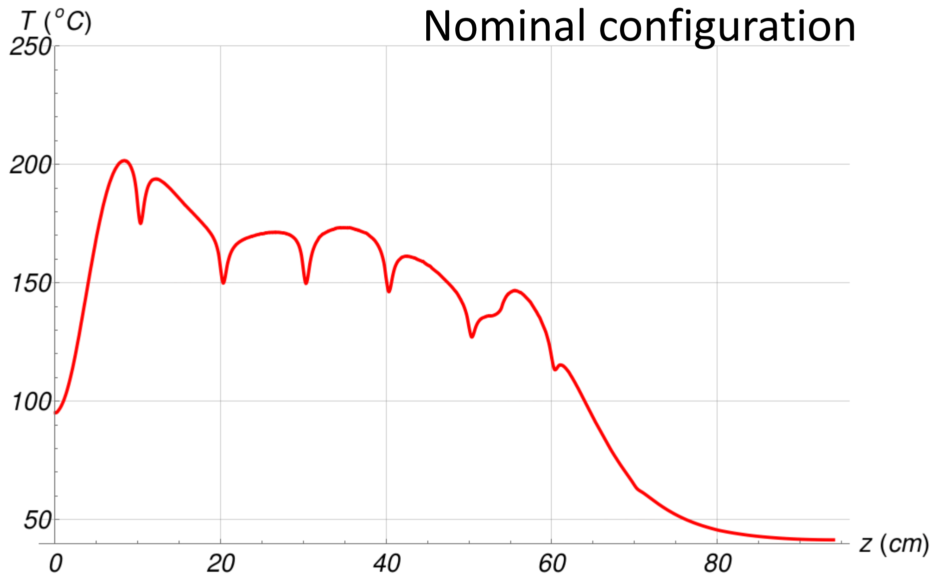


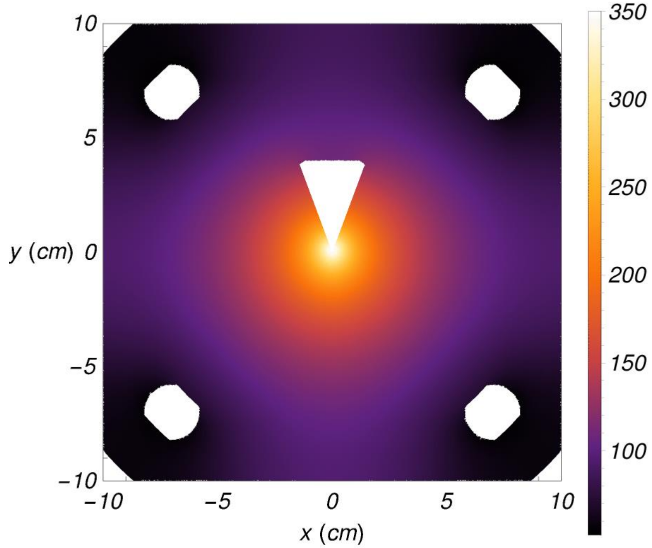


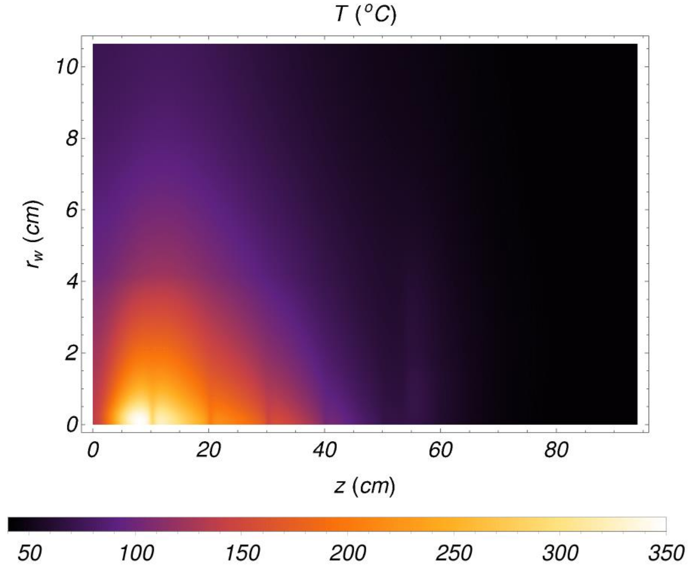
Comparison with beam angled by -1mrad in Y

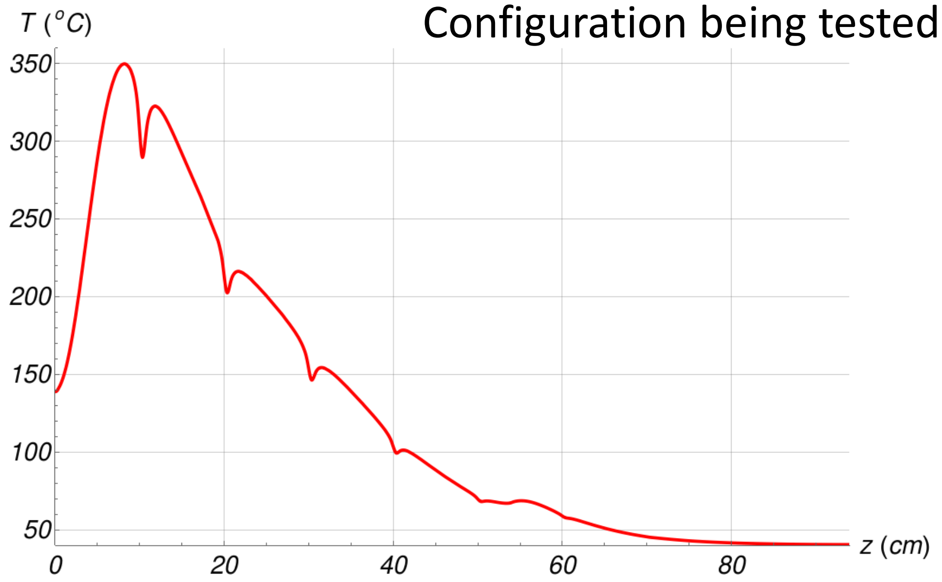






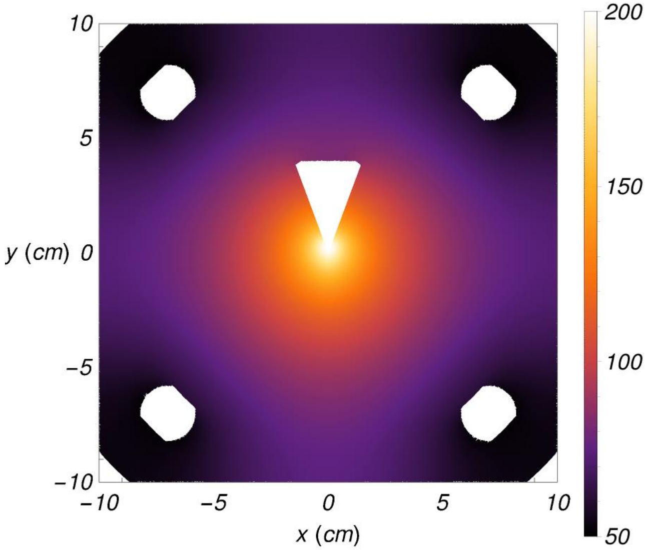


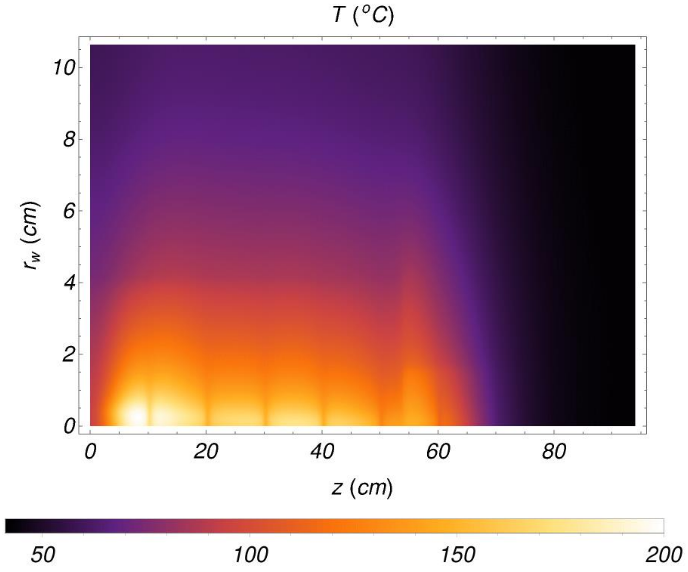


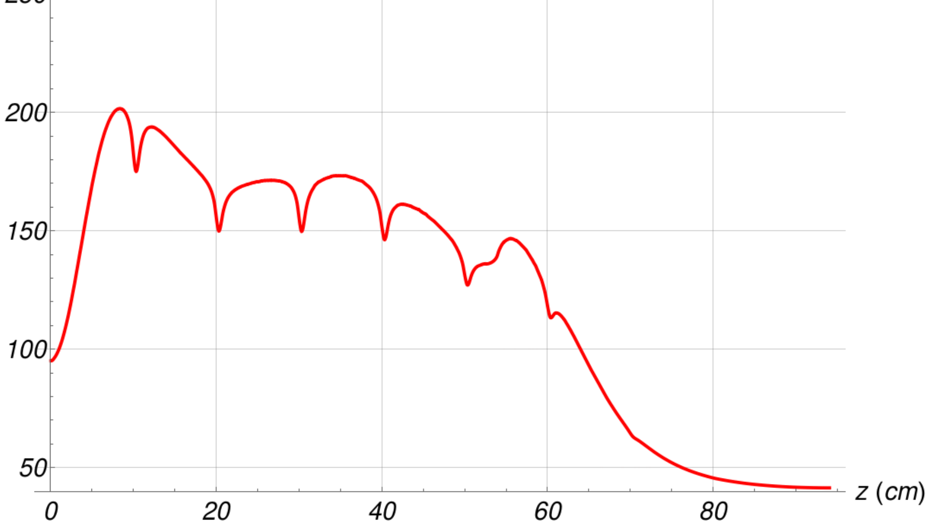


Comparison with beam shifted by +1mm in X

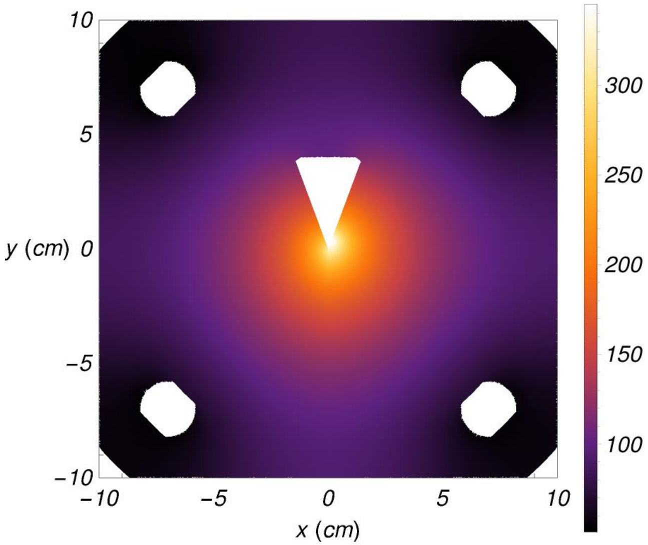
Nominal configuration

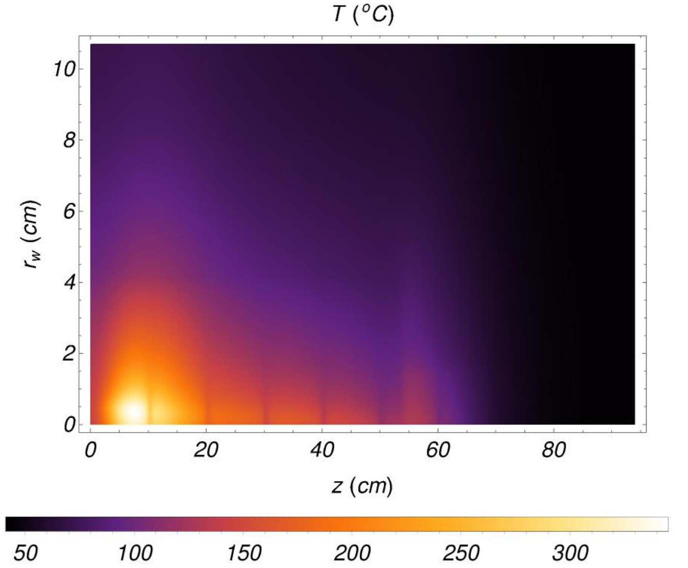


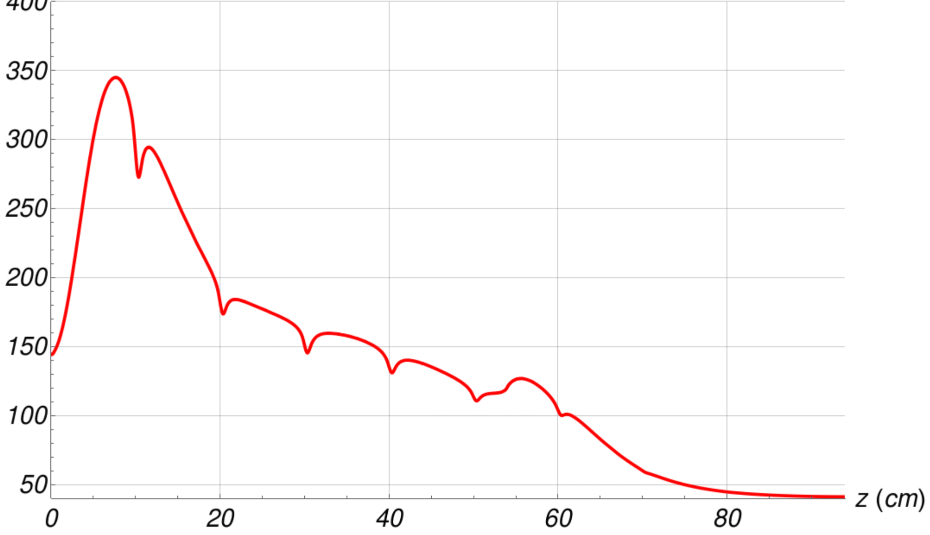




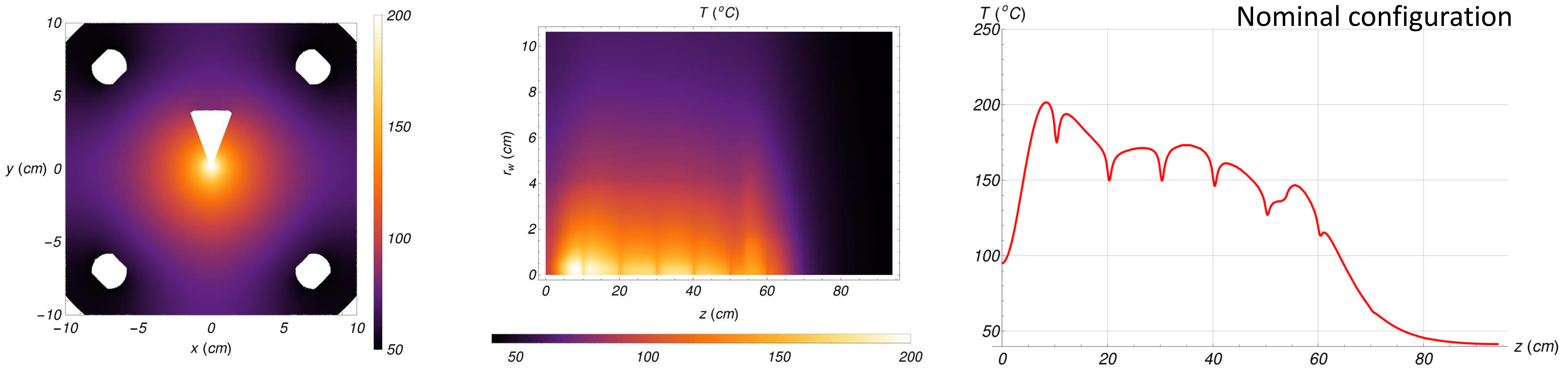
Configuration being tested

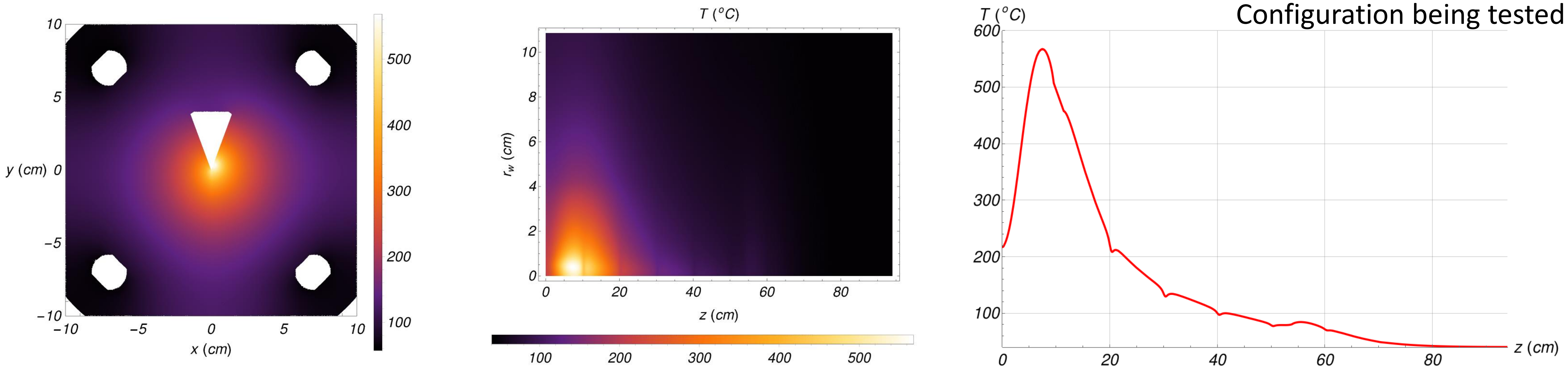




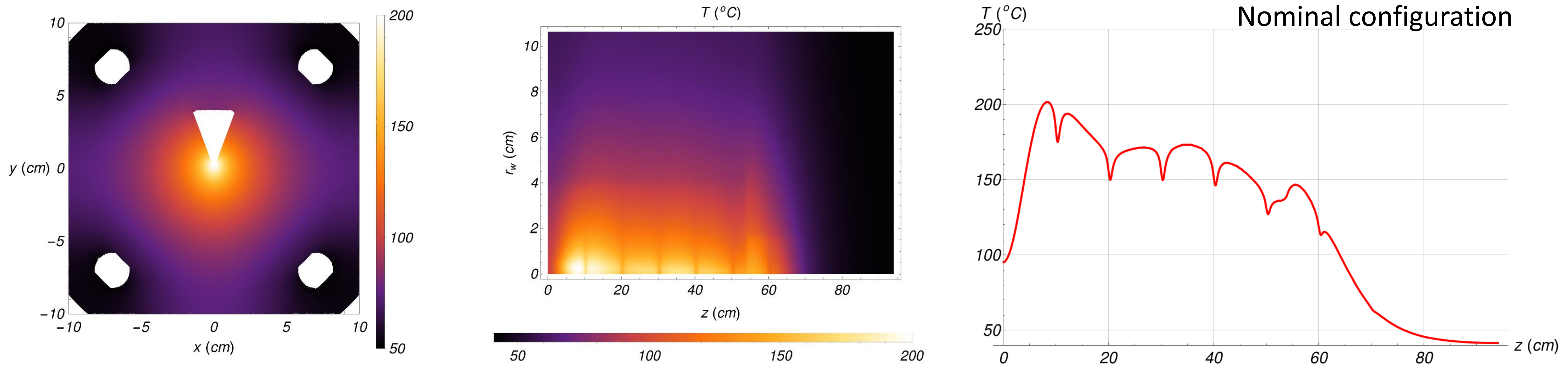


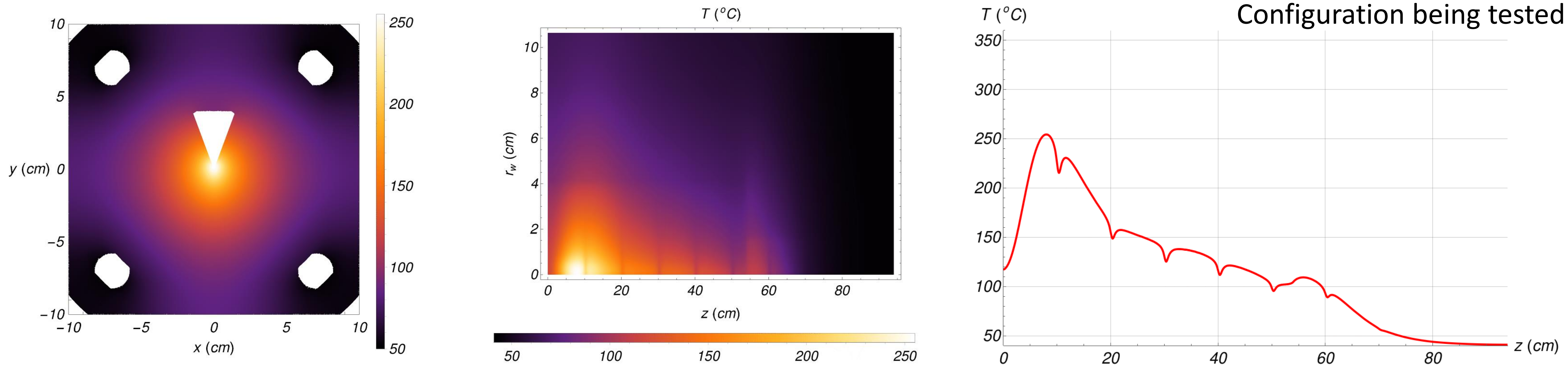
Comparison with beam angled by +1mrad in X





Comparison with 20% R.L. radiator





Conclusions

- Temperatures in the absorber for all currently available tests from Pavel have been calculated.
- Temperatures from all tests look acceptable except when the electron beam shifts in the horizontal direction by about 2mm or more.
  - This needs to be looked at by Tim to understand how much of a problem this is and to see if any mitigation measures may be needed.
  - We may require that the electron beam be shut off when the beam positions deviations are larger than 1mm.
- More tests configurations need to be simulated by Pavel.
  - Asymmetric 2D Gaussian distribution for the electron beam profile in the xy-plane.
  - Symmetric Gaussian beam with larger widths.
  - Beam with 10^{-4} relative level of halo under the Gaussian peak.
  - More tests may be added as we go.