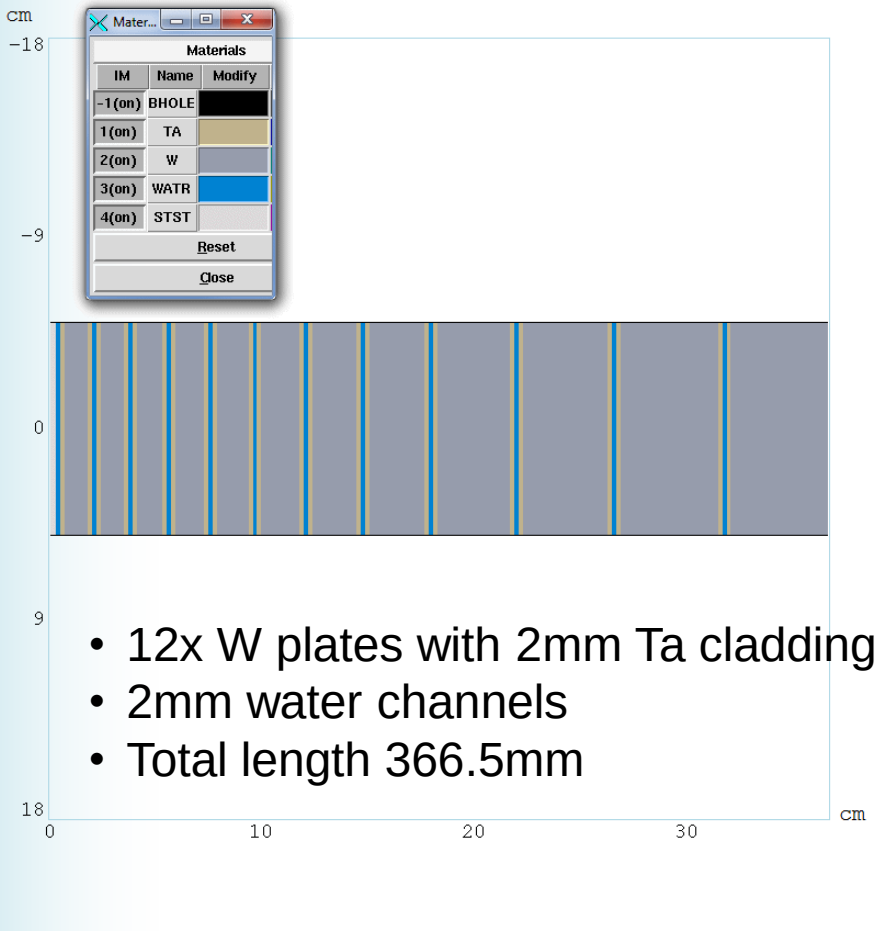
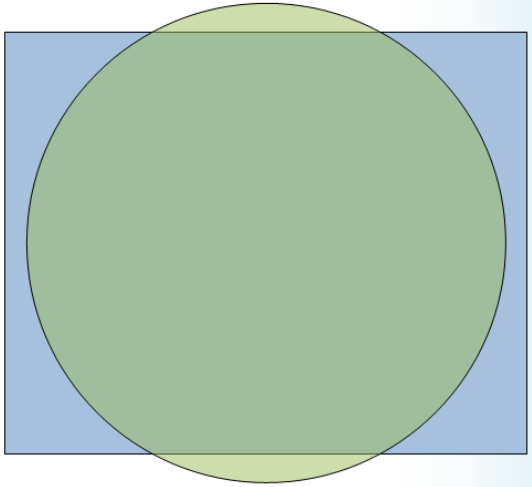
Status of MARS Simulations of ISIS Targets

1. Sensible heat values for TS1, TS2
2. Comparisons MARS1510 → 1512
3. DPA still controversial

1. TS1 Simplified Geometry

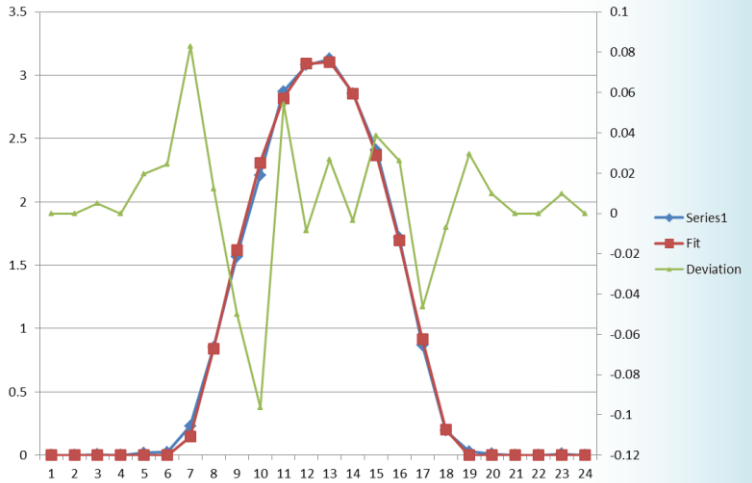




- 12x W plates with 2mm Ta cladding
- 2mm water channels
- Total length 366.5mm

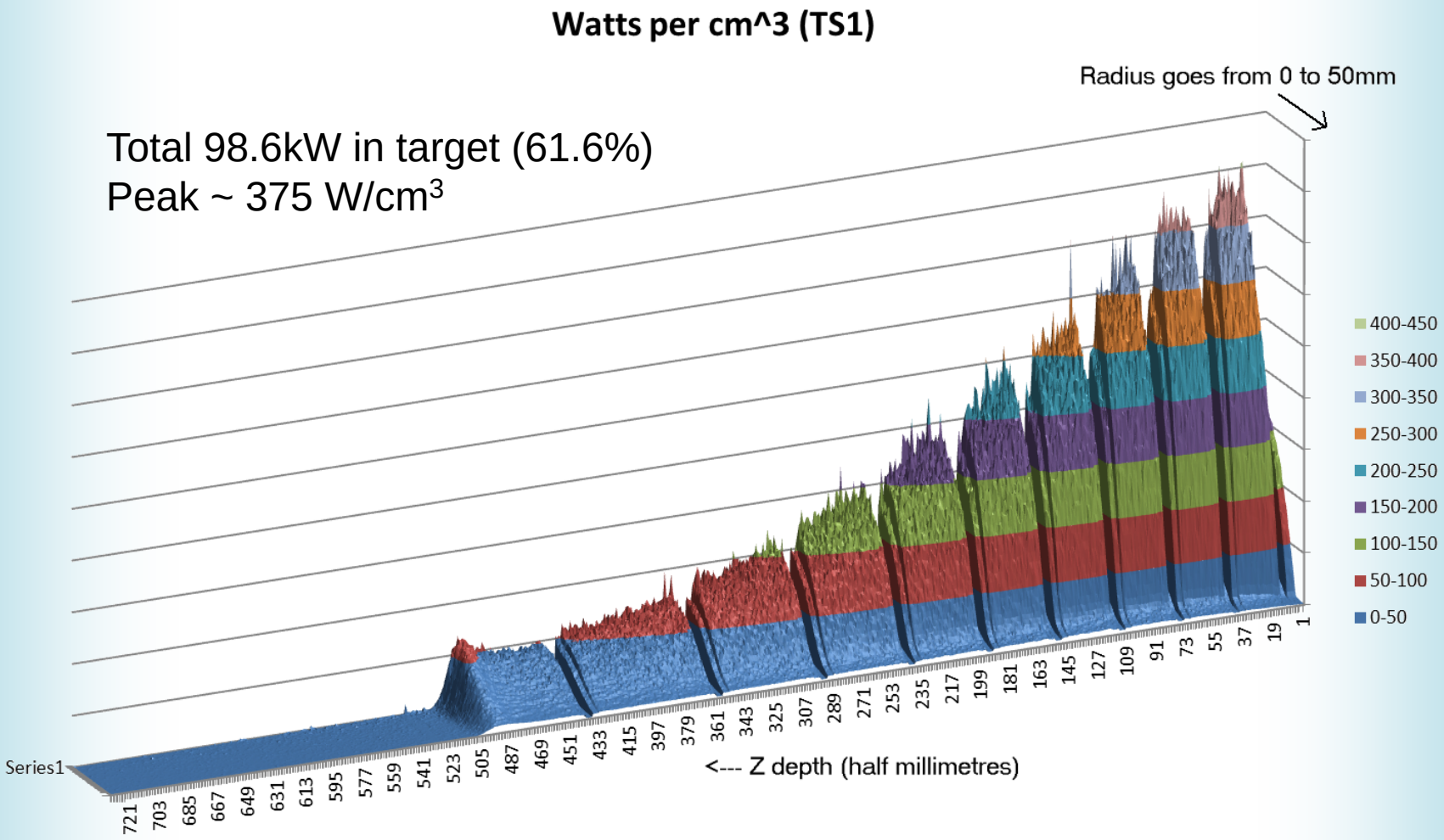
Real 109×88mm rectangular cross-section approximated by 100mm Ø cylinder

TS1 Input Beam

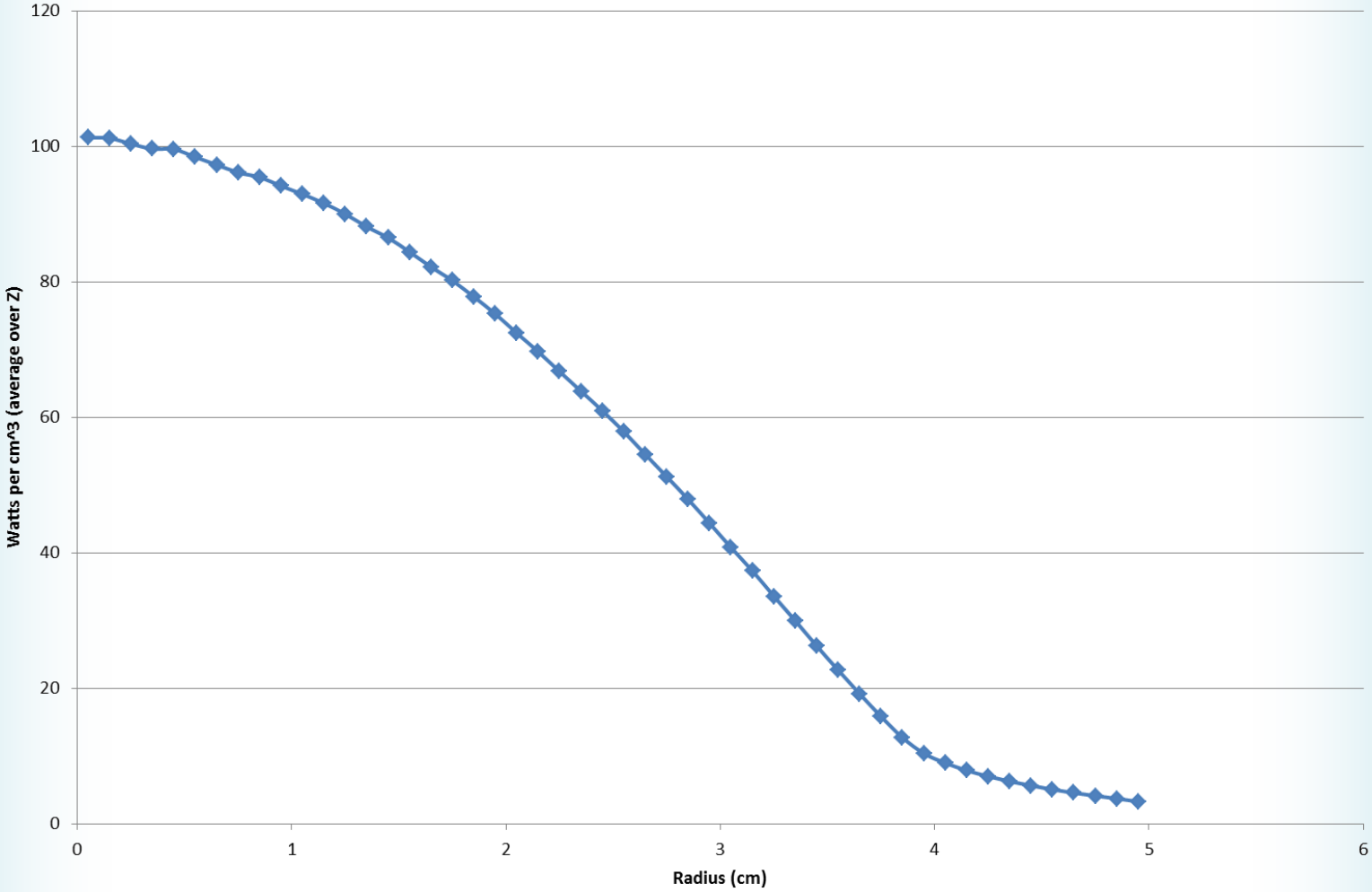


- 800MeV protons
- Scaled to 160kW
  - 200uA beam current
- 4D waterbag model fits observations
  - $x_{max} = y_{max} = 39mm;\ x'_{max} = y'_{max} = 3mrad$
    - 117mm.mrad total geometric emittance
    - 2D projection of waterbag is circular parabolic $(1-r^2)$
  - From measured 1D beam profiles and MAD model
    - Thanks to Dean Adams for the data

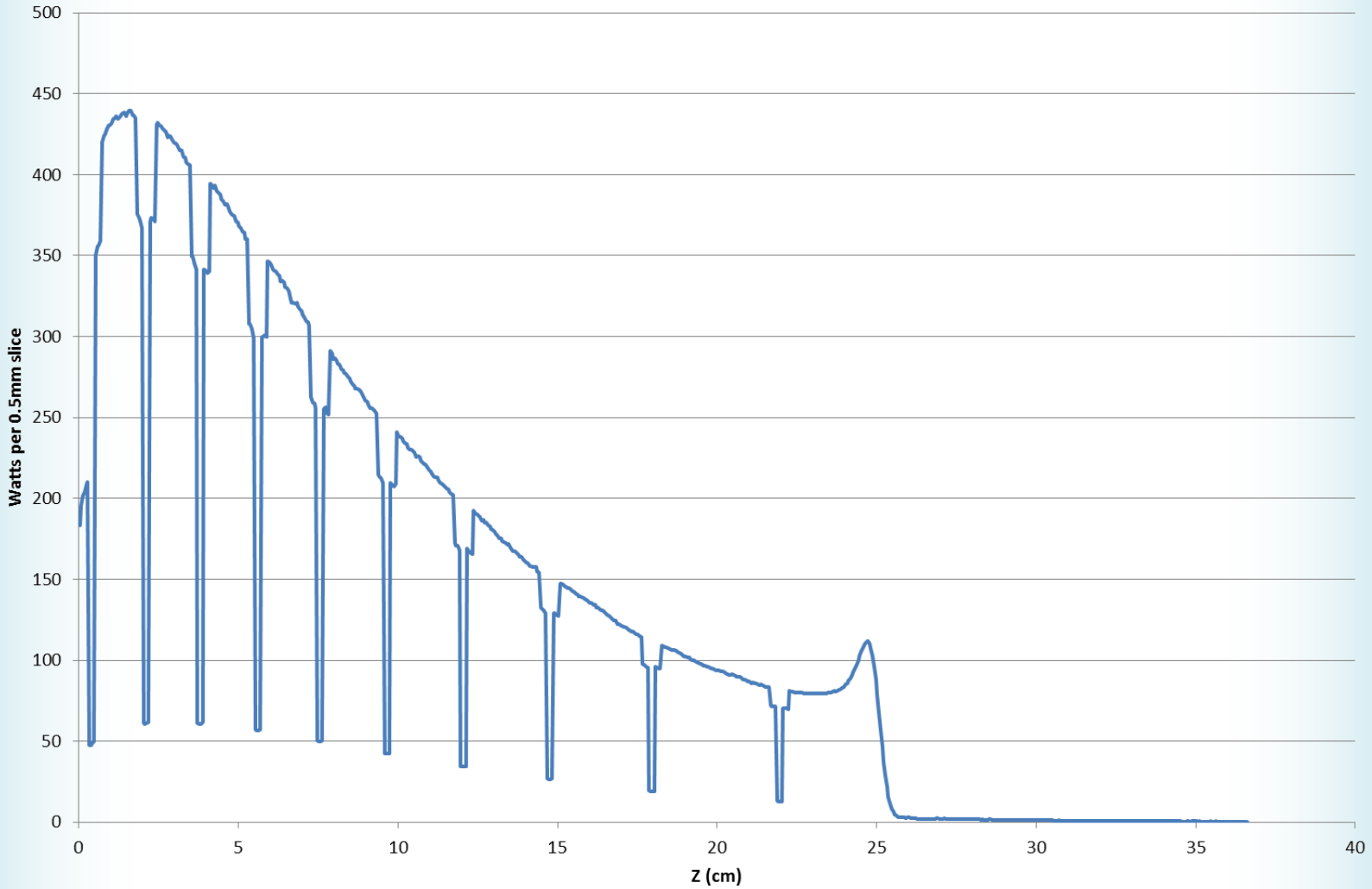
TS1 Heat Distribution (MARS1512)



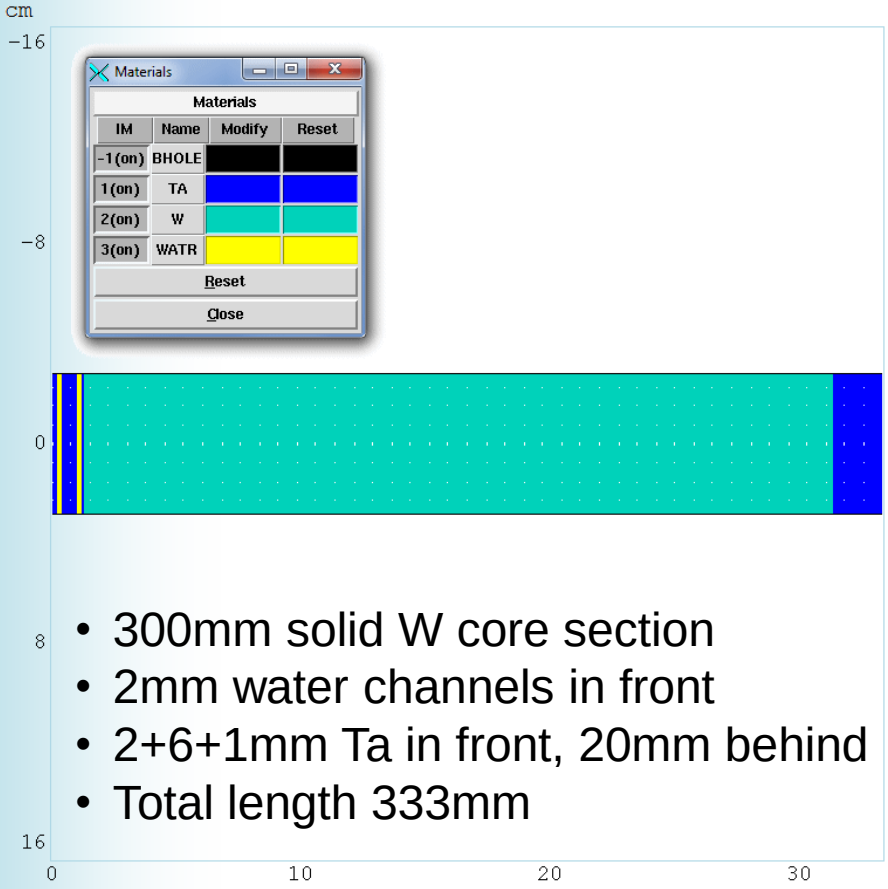
TS1 Heat Distribution (Radial)



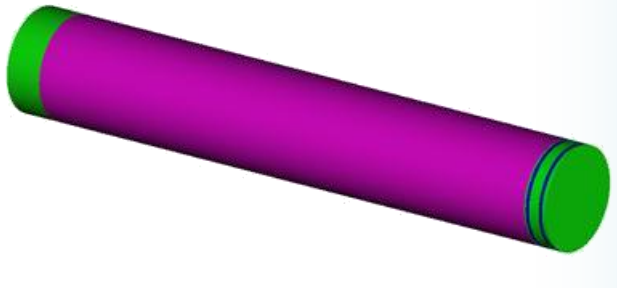
TS1 Heat Distribution (Z)



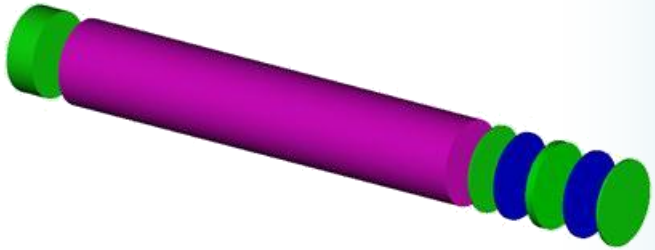
TS2 Simplified Geometry



- 300mm solid W core section
- 2mm water channels in front
- 2+6+1mm Ta in front, 20mm behind
- Total length 333mm



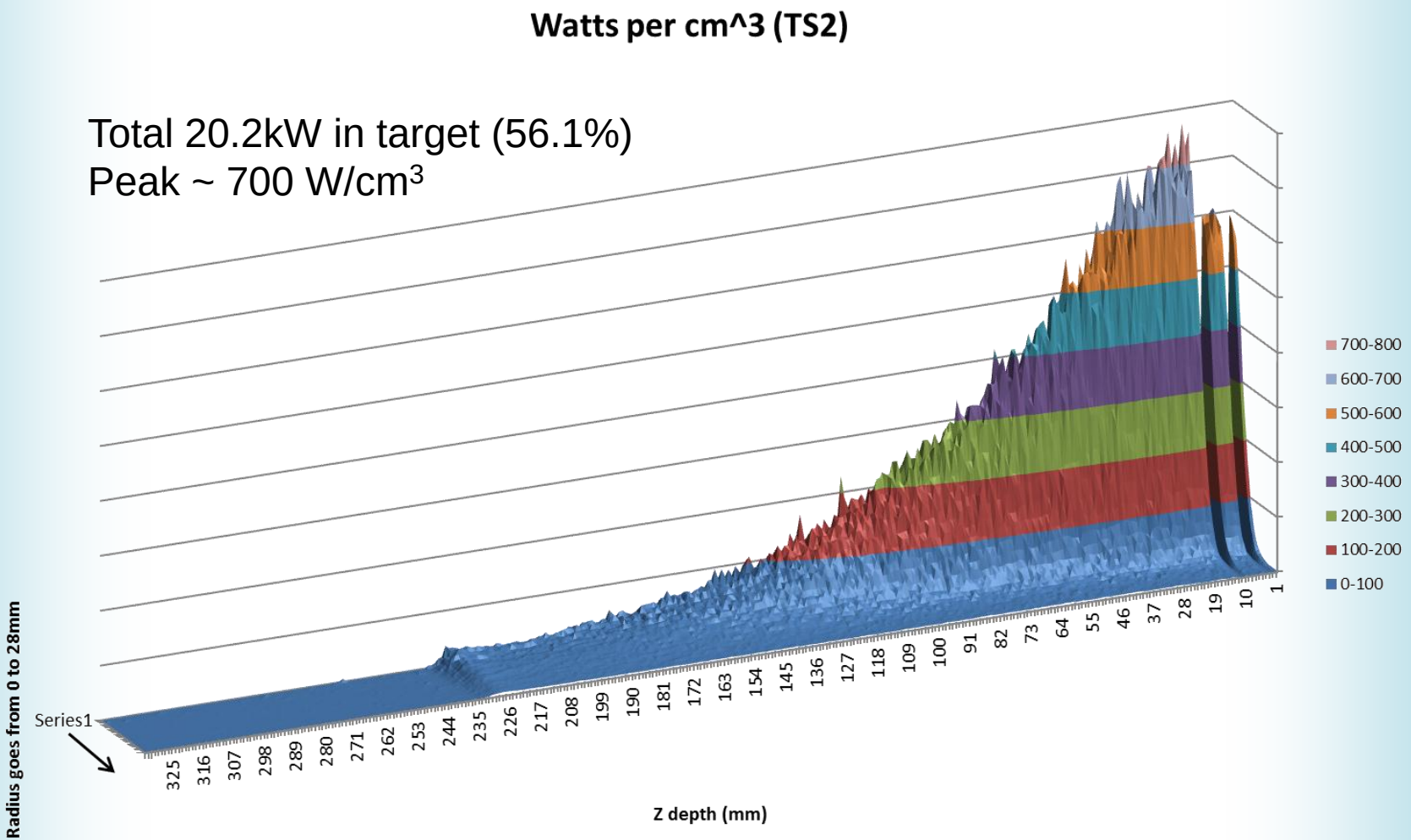
56mm Ø cylinder



TS2 Input Beam

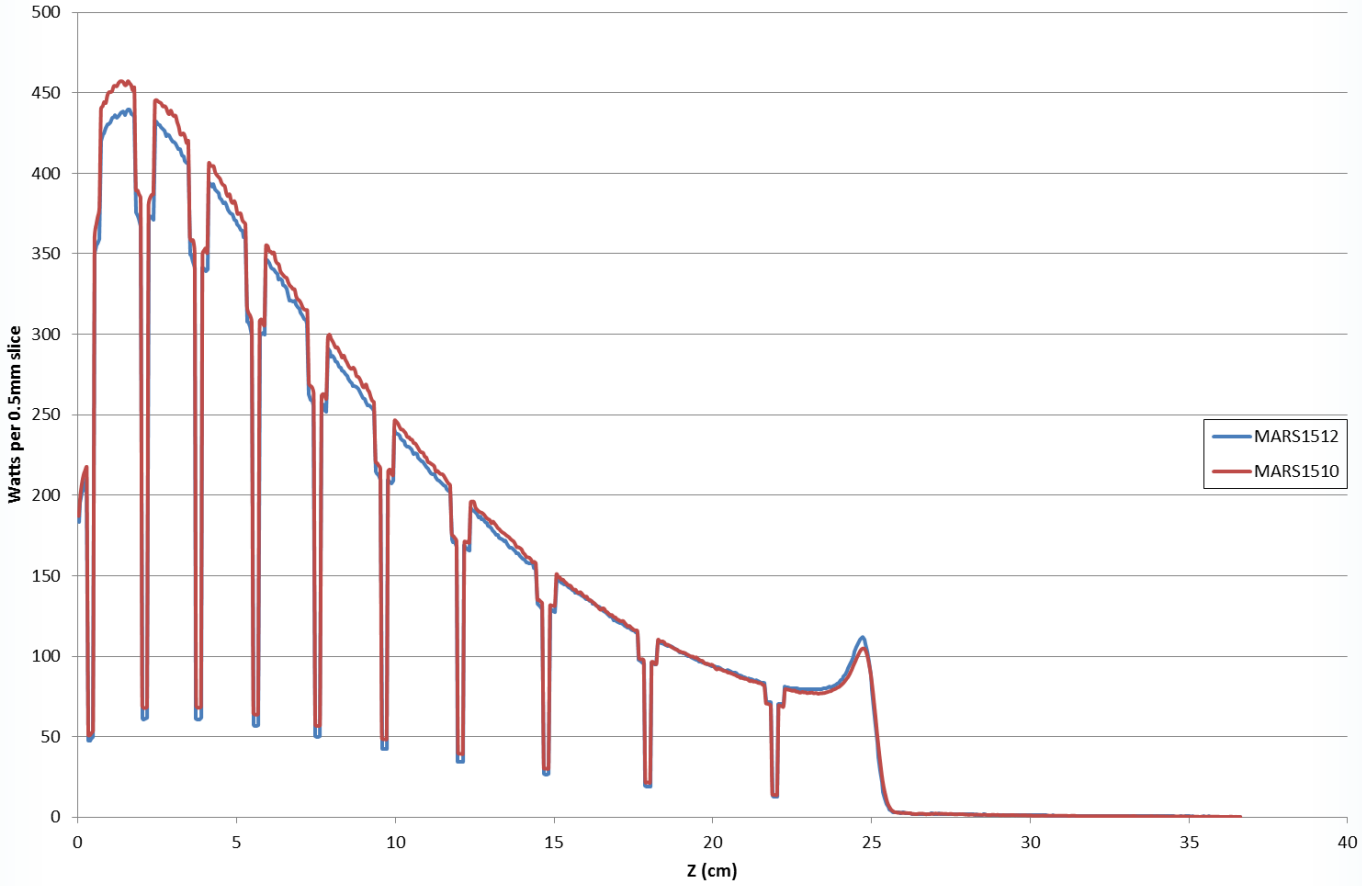
- 800MeV protons
- Scaled to 36kW
  - 45uA beam current
- Haven't got any measured profiles yet
- Was told to use circular Gaussian
  - σ = 6mm; 3σ = 18mm; $4\frac{2}{3}\sigma$ = 28mm = r_{target}
  - Parallel beam

TS2 Heat Distribution (MARS1509)

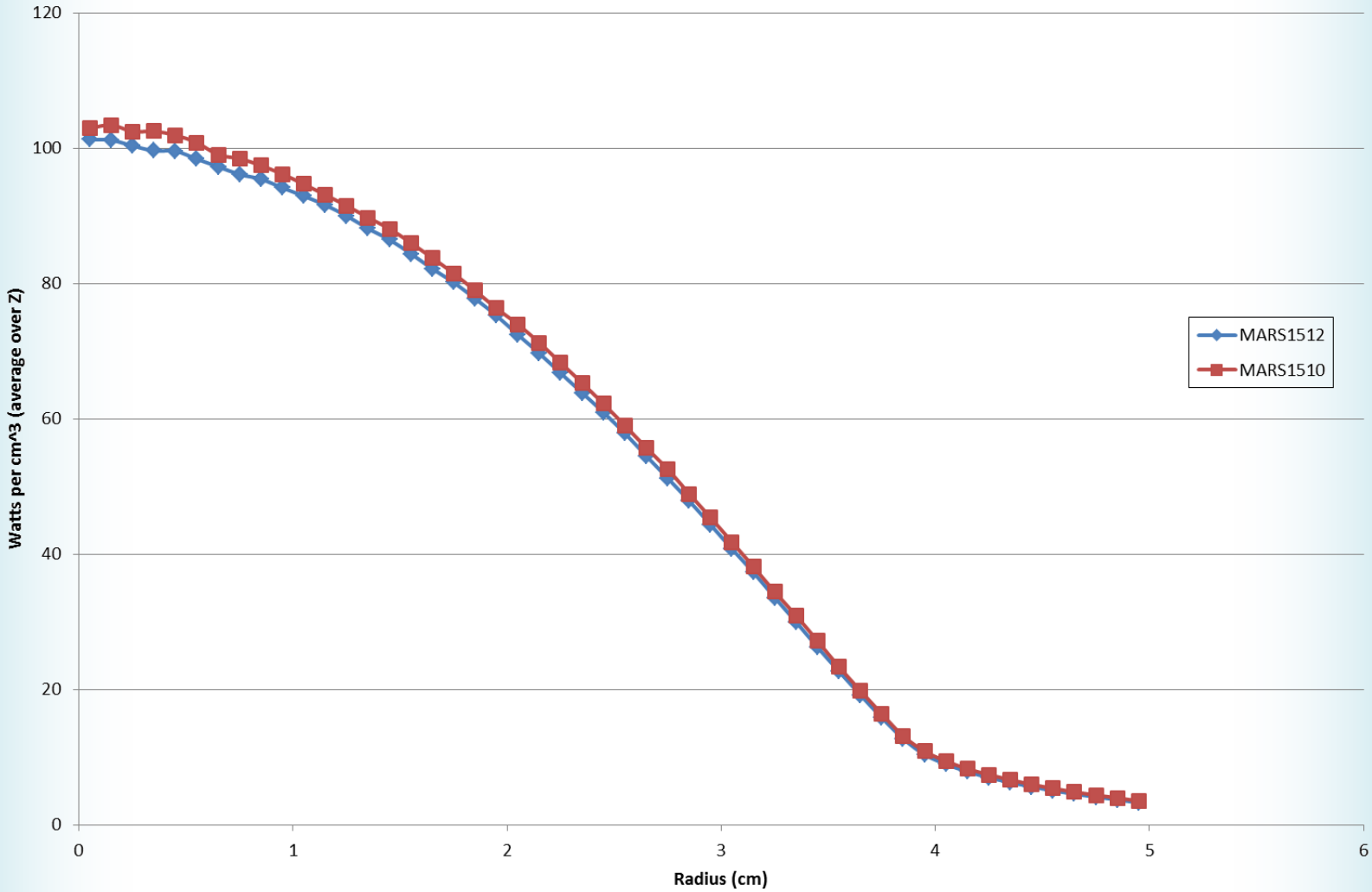


2. Compare MARS1510 to 1512

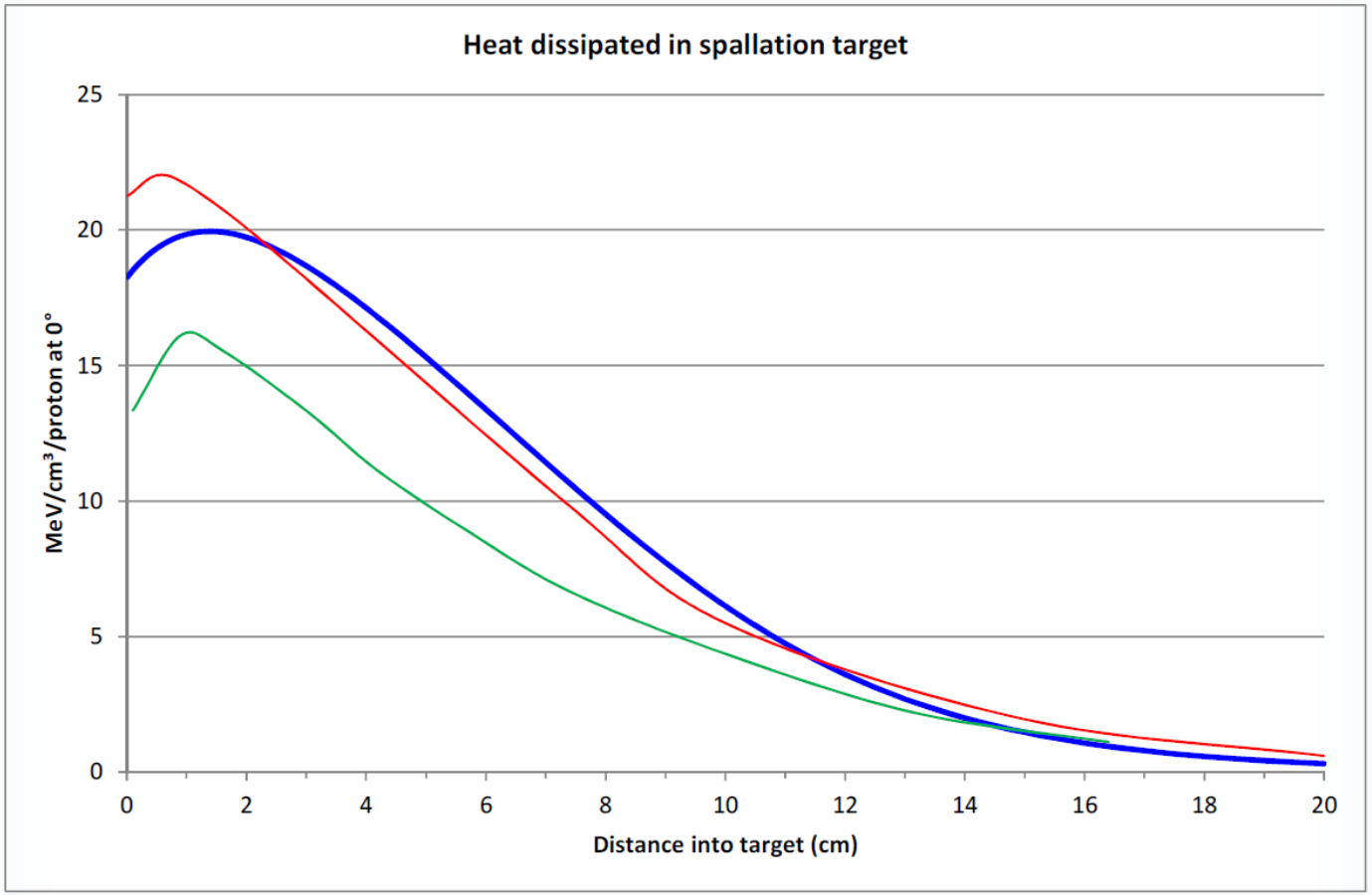
- TS1 has been simulated with both codes



TS1 Heat Distribution (Radial)

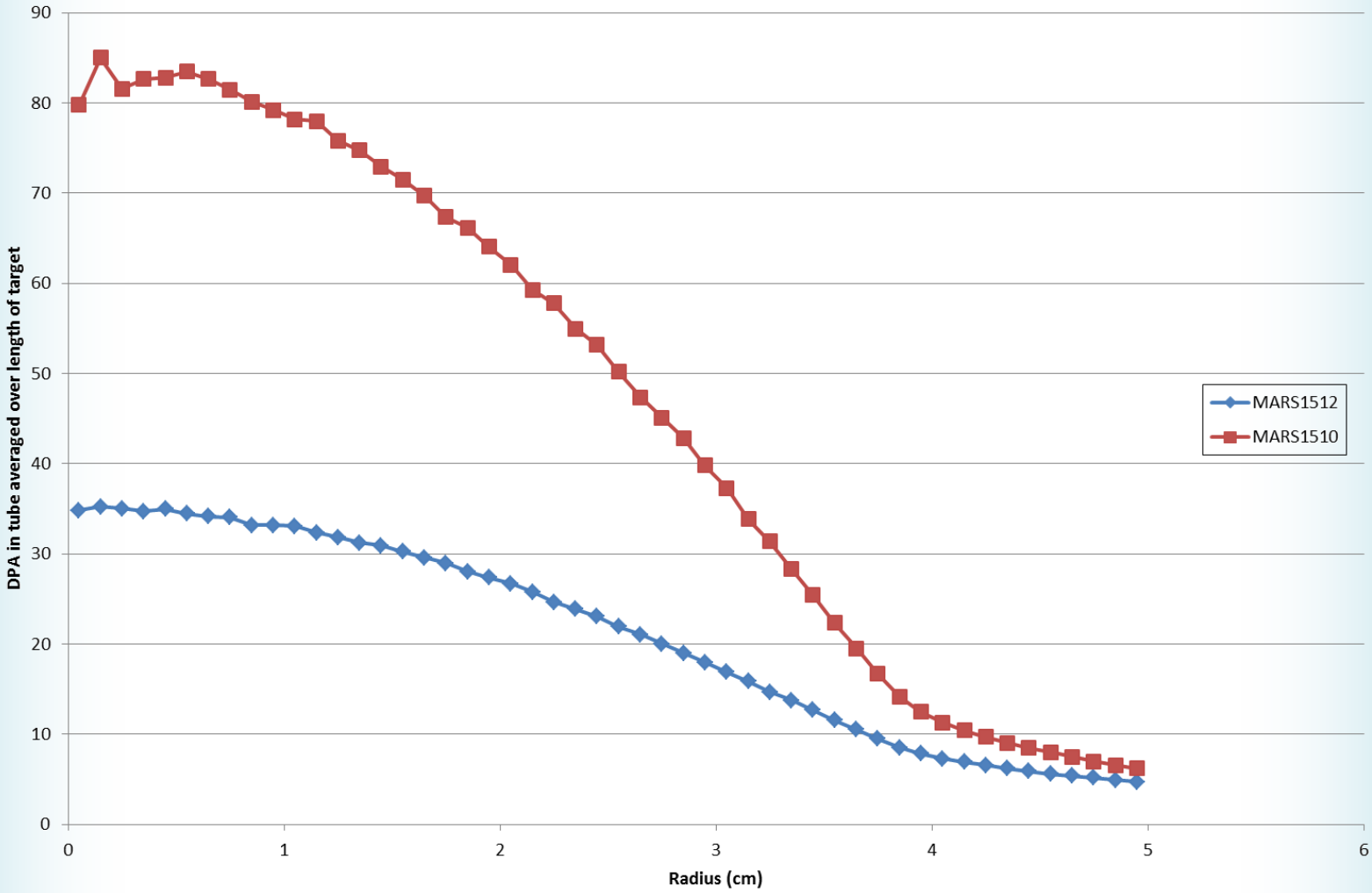


David Findlay's TS2 Analytic Model

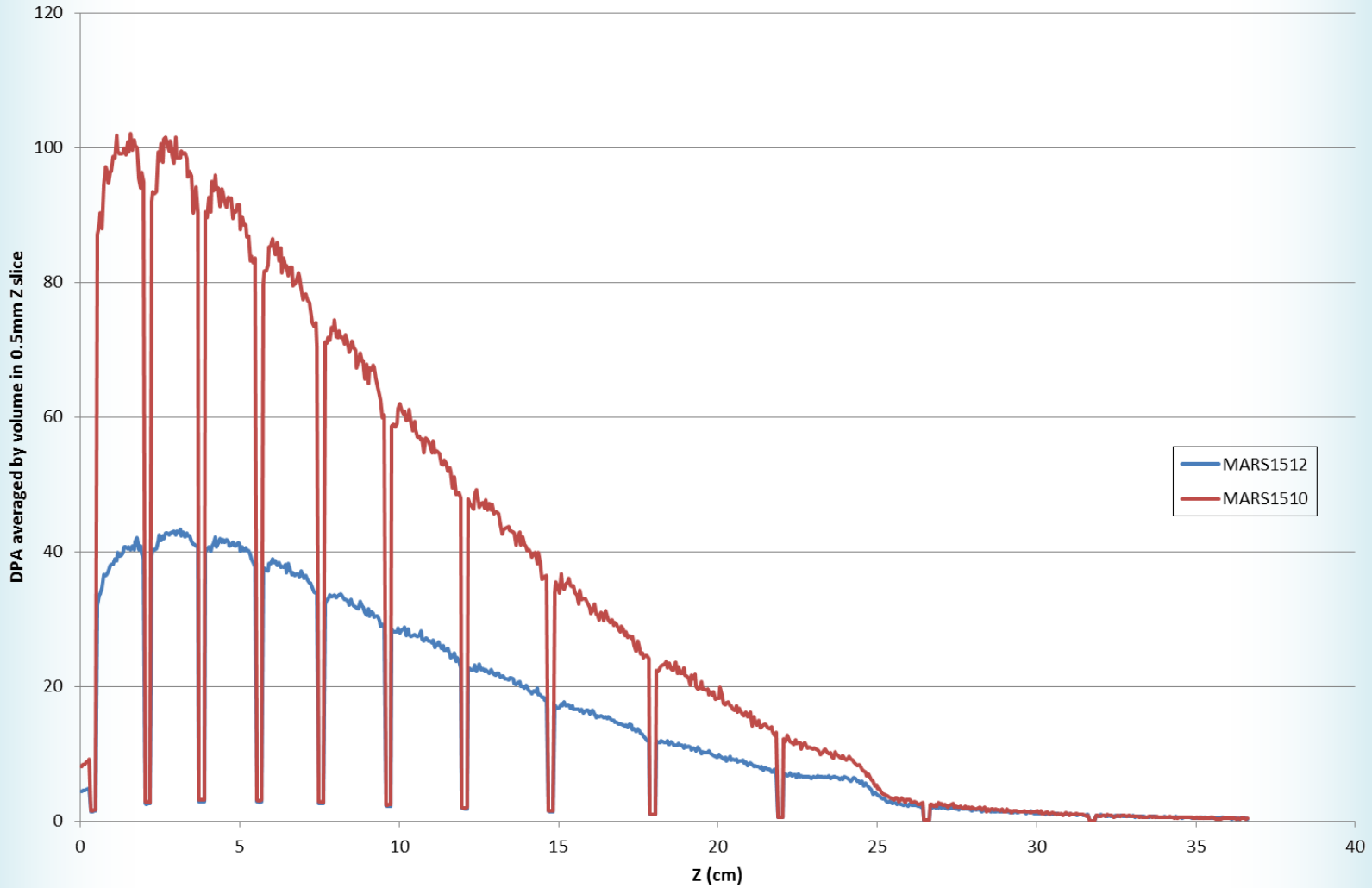


Comparison between present analytic model (blue) and two Monte Carlo computations with MCNP (Robbie Scott) (red) and MARS (Stephen Brooks) (green).

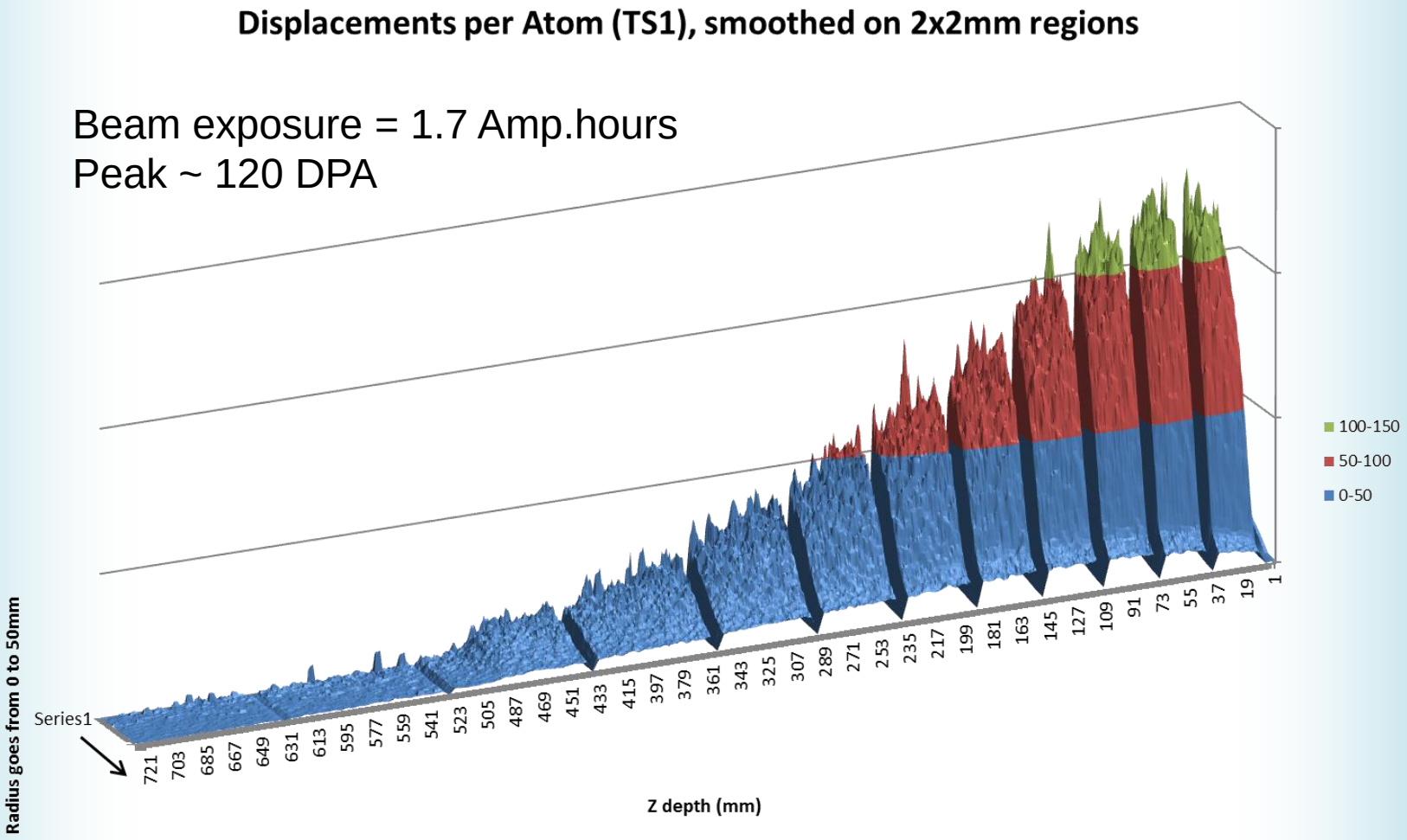
3. DPA in TS1 (MARS1512 & 10)



DPA in TS1 Longitudinally



DPA in TS1 (MARS1512)



Comparing with Other Sources

- 1.7 A.h because of TS1 target in this paper:
  - *Summary of the results from post-irradiation examination of spent targets at the FZ-Juelich*, J. Chen, G.S. Bauer, T. Broome, F. Carsughi, Y. Dai, S.A. Maloy, M. Roedig, W.F. Sommer, H. Ullmaie, Journal of Nuclear Materials **318**, pp.56–69 (2003).
- However…

Table 2
Irradiation conditions

	LANSCE Water-Degrader		LANSCE Beam window	PSI-Window	ISIS target
	IN 718	AISI 304L	IN718	DIN 1.4926	Pure Ta
Protons (A h)	5.29	5.29	3.41	2.83	1.74
σ_x/σ_y (mm)	–	22.6/28.8	–	16.3/23.6	17.0/20.7
Peak fluence (p/m^2)	2.9×10^{25}	2.9×10^{25}	6.4×10^{25}	2.6×10^{25}	1.7×10^{25}
Max. irrad. temp. (°C)[a]	250	250	400	250	200
Max. dpa	8.5	8.5	20	6.8	11
Max. He (appm)	1510	1680	3330	1510	580
Max. H (appm)[b]	5890	5270	13 000	4720	–

[a] The Max. irrad. temp. refers to the maximum temperature which the component has experienced in the beam center and operating the spallation neutron source at maximum power.

[b] The values represent the hydrogen produced in materials. But there are energetic losses and diffusional losses depending on geometry of the parts, the solubility and diffusivity of hydrogen, and the microstructural sinks in the materials.

Paper's Ta DPA Calculation

Taking a displacement damage cross-section of 2900 b for 304L and IN 718 [8], 2600 b for DIN 1.4926 [9] and 6650 b for Ta [10], the maximum displacement doses are 8.5, 20, 6.6 and 11 dpa for 304L, IN 718, DIN 1.4926 and pure Ta, respectively.

[10] D. Filges, C. Mayr, R.D. Neef, H. Schaal, A. Tietz, J. Wimmer, ESS report no. 96-45-T (1996).

A summary of the irradiation conditions is given in Table 2. It should be noticed that the contribution of the fast neutrons to dpa and transmutation products is not included. At the position of the Water-Degrader, the LANSCE- and the PSI-Window, the flux of neutrons was very low and their contributions were estimated to be less than a few percent of the proton-induced values in the beam centre, while it is somewhat higher in the case of the ISIS target.

Nikolai Mokhov's Advice

- No particular opinion on whether 120 DPA is excessive
- Thinks MARS1512 is much improved over MARS1510
- *"I believe that contribution of neutrons and their reactions below 14 MeV can be crucial. The only way to describe such neutrons as precise as possible in MARS is to run it with the ENDF/B ("MCNP") x-sections"*

Conclusion & Future Work

- Heat deposition calculations seem quite stable
- ESS note is in a box at RAL somewhere
- Waiting for Nikolai's reply on how to activate MCNP mode
  - Might then be possible to do a DPA calculation excluding fast neutrons to compare with paper
- May contact Nik Simos (BNL) regarding DPA sensible values/benchmarking