

# MedAustron fluka studies

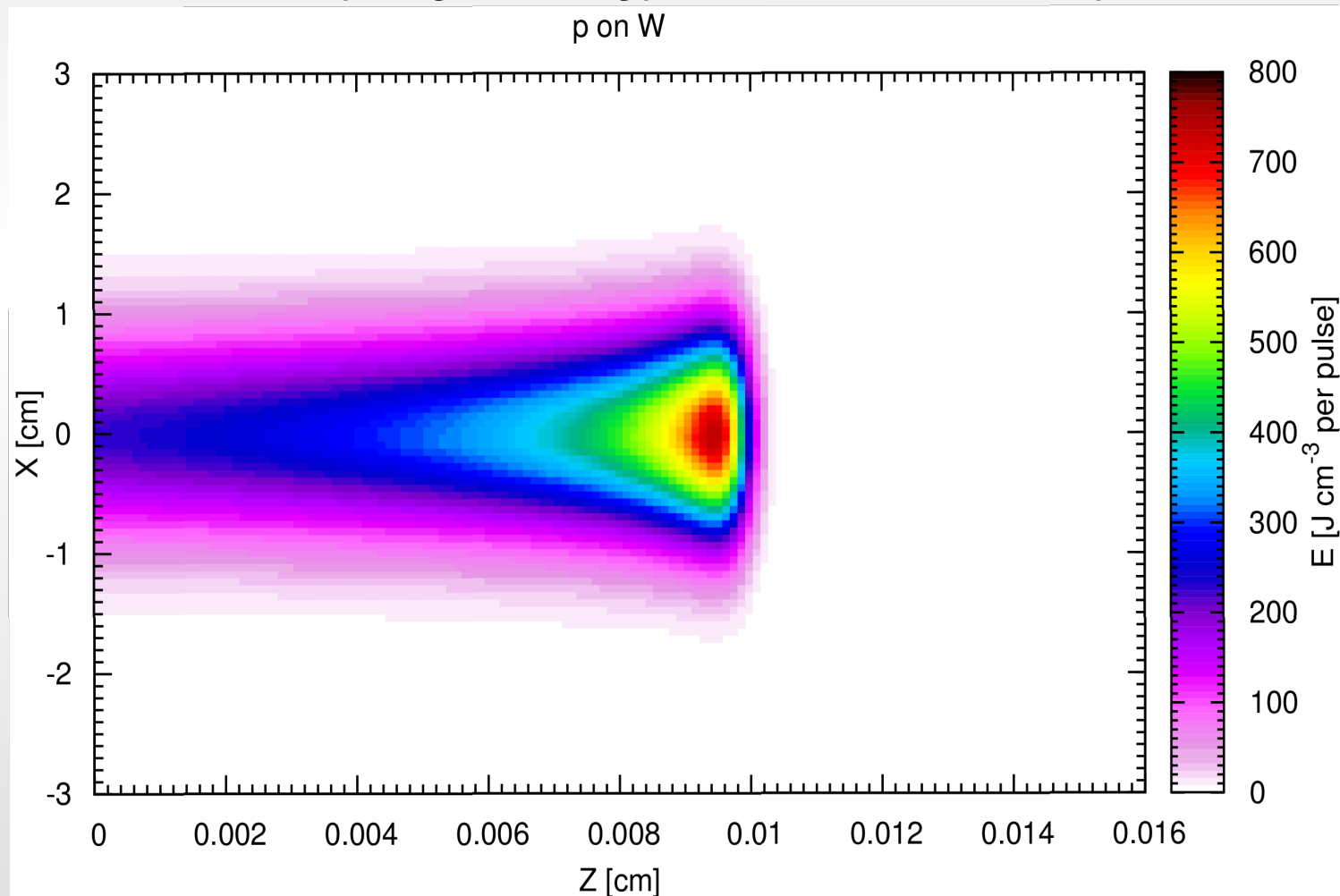
A. Christov, V. Vlachoudis

# MEBT Dump - Tungsten

- Considered two beams:
  - Protons, 7 MeV
    - Pulse:  $500\mu\text{s} * 5\text{E}15 \text{ particles/s} = 2.5\text{E}12$  protons
  - Carbon ions, 7 MeV/u
    - Pulse:  $500\mu\text{s} * 2\text{E}14 \text{ particles/s} = 1\text{E}11$  C ions
- Simple geometry: Block of tungsten

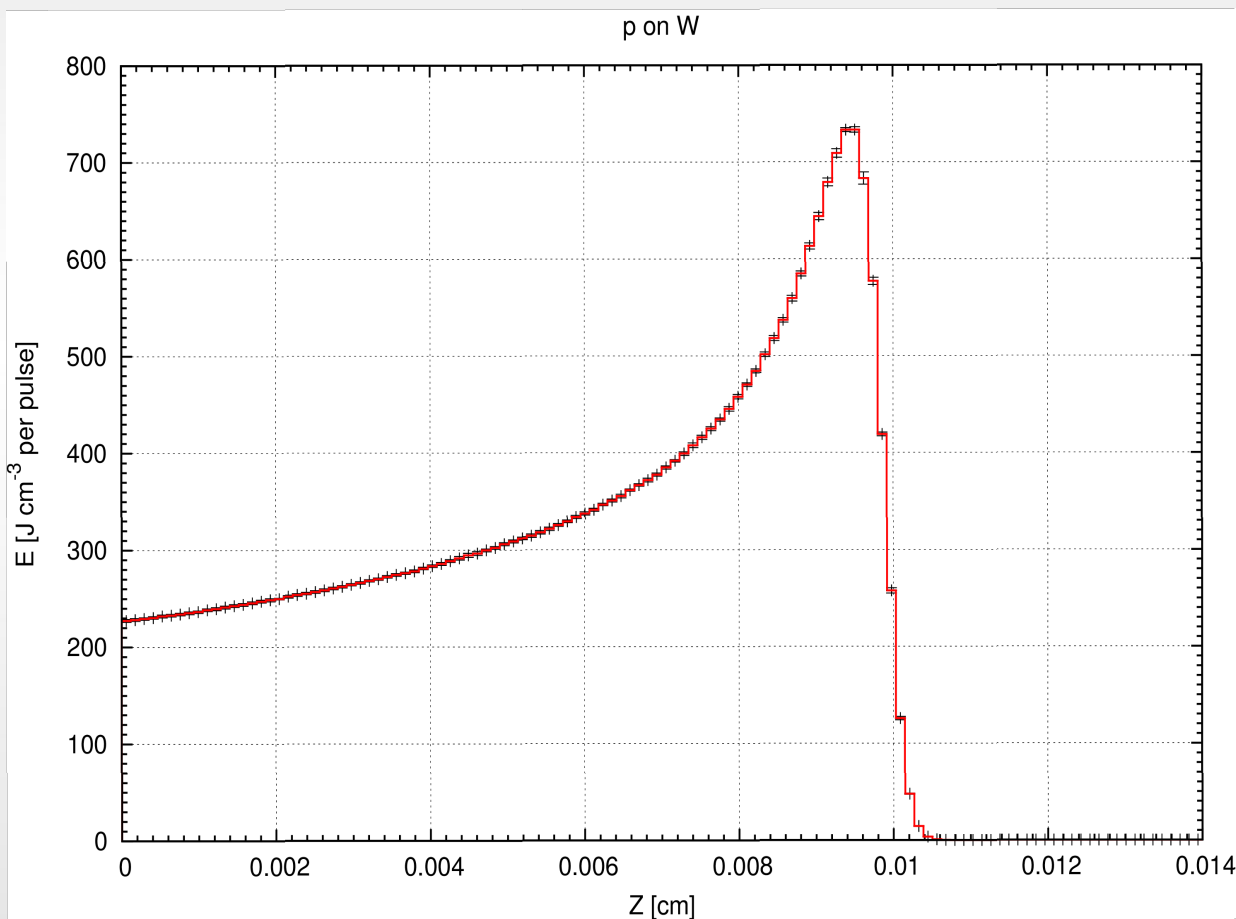
# 7 MeV protons reach in tungsten

- Peak energy deposition around 0.1 mm deep
  - Relatively high energy deposition density



# Peak energy deposition, protons

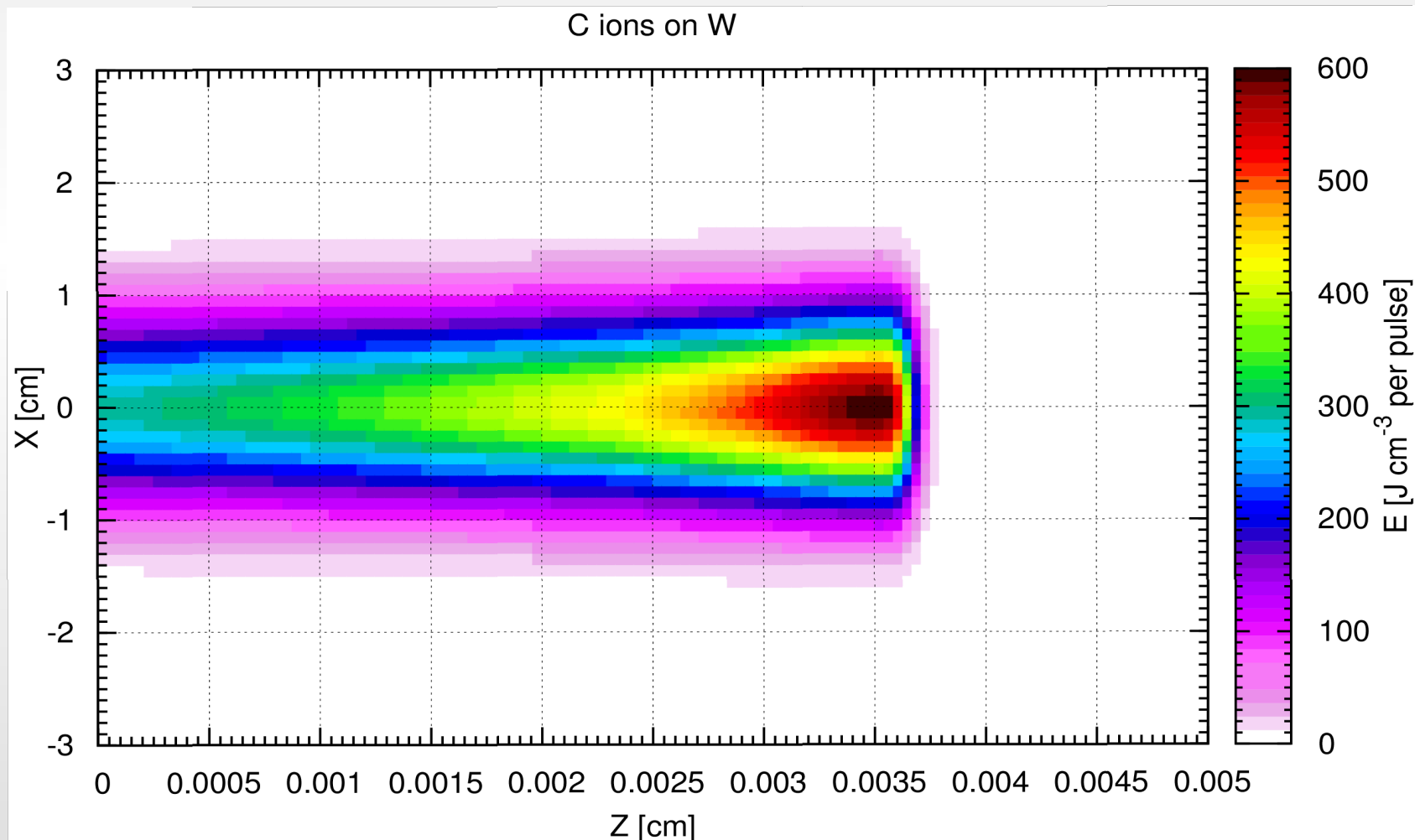
- Beam direction - along the Z axis



- Max Energy deposition:  
735 J cm<sup>-3</sup> per pulse

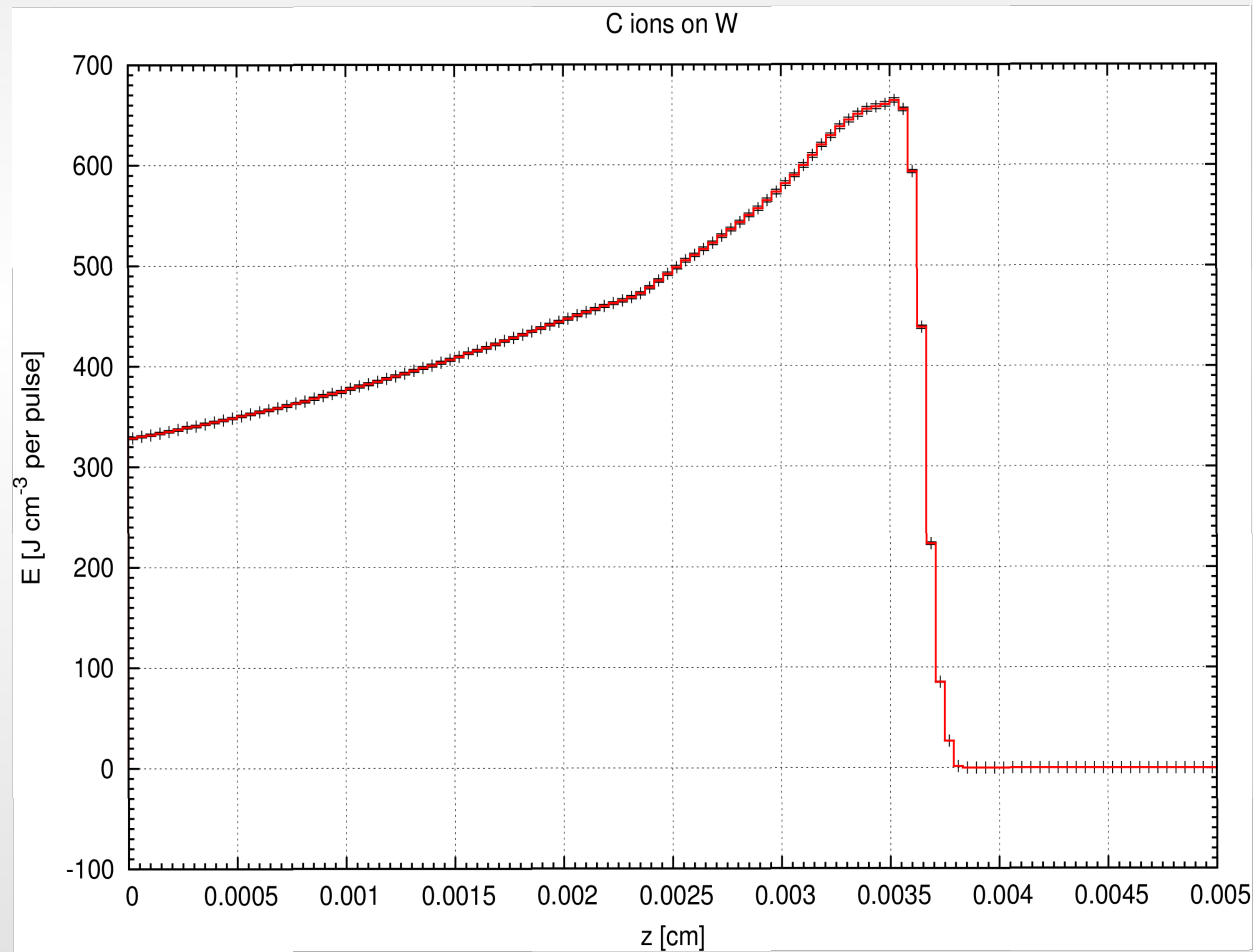
# 7 MeV/u C ions reach in tungsten

- Only 40  $\mu\text{m}$  deep, even higher energy deposition density



# Peak energy deposition, C ions

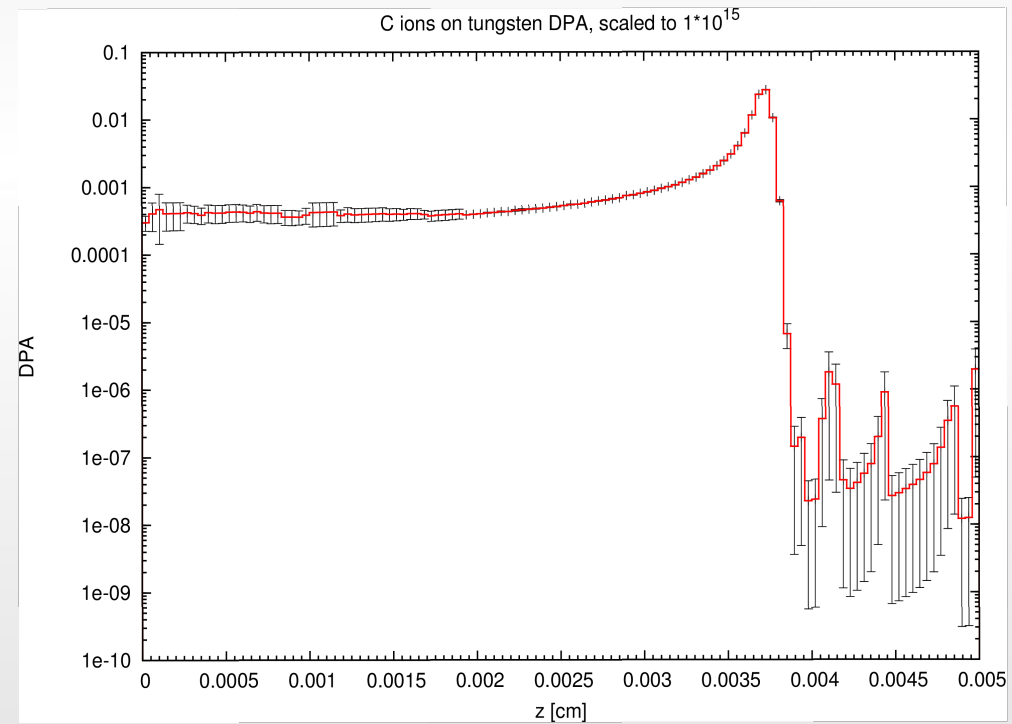
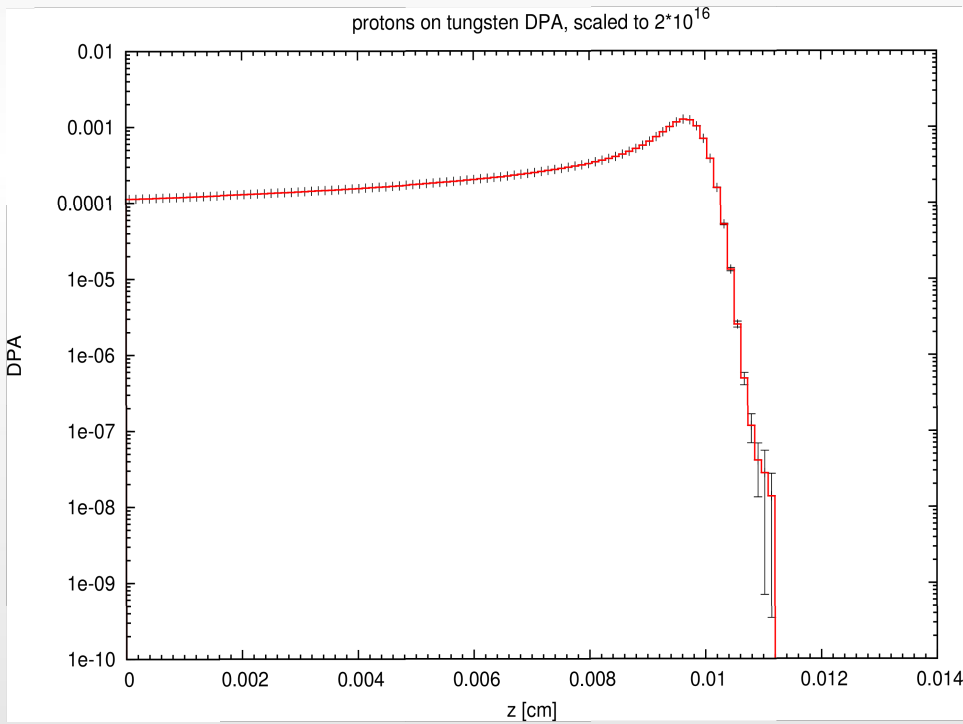
- Beam direction - along the Z axis



- Max Energy deposition:  
665 J cm<sup>-3</sup> per pulse

# MEBT dump – Displacement per Atom (DPA)

- Scaled to one year dose
  - $2 \cdot 10^{16}$  protons
  - $10^{15}$  C ions



# MEBT Conclusions

- Both protons and C ions have similar energy deposition densities **per pulse** (around  $700 \text{ J cm}^{-3}$  per pulse)
- In both cases the energy is deposited very close to the surface.
  - 0.1 mm in the case of protons
  - $40 \mu\text{m}$  in the case of C ions
- If necessary the energy deposition density can be reduced by impacting a tilted surface (Example for protons):
  - $10^\circ$  impact angle  $\rightarrow$  peak dep. Energy  $\sim 400 \text{ J cm}^{-3}$  per pulse
  - $5.5^\circ$  impact angle  $\rightarrow$  peak dep. Energy  $\sim 360 \text{ J cm}^{-3}$  per pulse



# Beam parameters – a crucial component

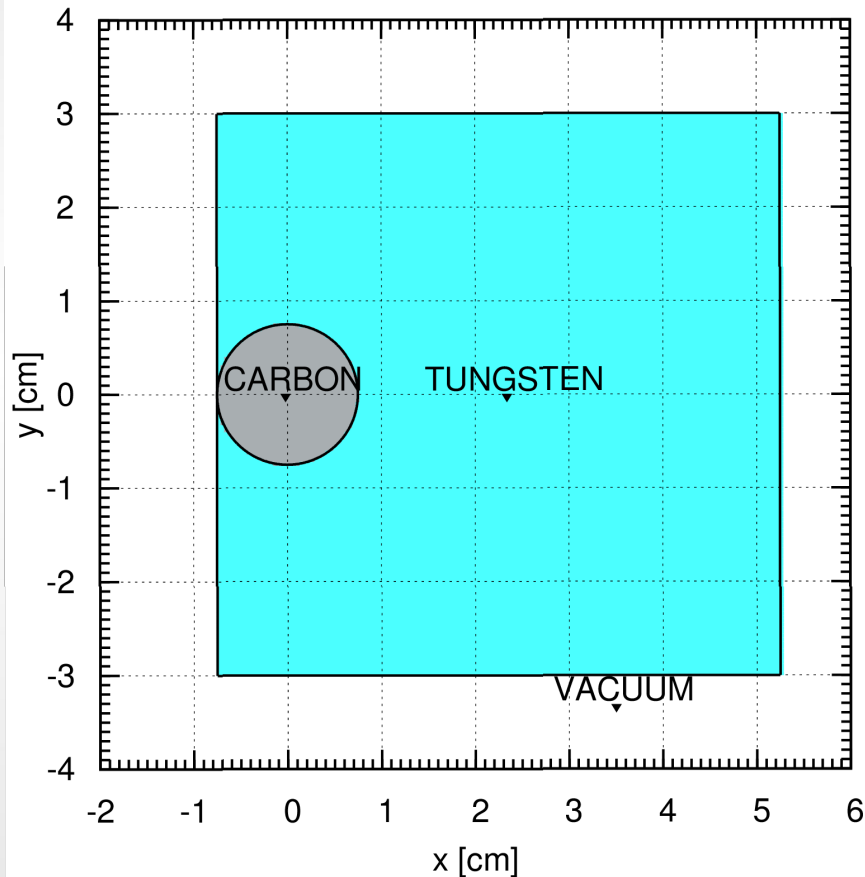
## Example for the C ions

- Original definition: beam current = 0.2 mA, 1 ms
  - $0.2 \text{ mA} * 1 \text{ ms} = 1.25 * 10^{12}$  particles in a pulse
- Second definition: 20 Watt; 7 MeV/u ; 0.5 ms
  - $20 \text{ [W]} * 0.5 \text{ [ms]} / 7 \text{ [MeV/u]} = 7.43 * 10^8$  particles in a pulse
- Latest definition:  $2 * 10^{14}$  particles  $\text{s}^{-1}$  during 0.5 ms
  - $2 * 10^{14} \text{ s}^{-1} * 0.5 \text{ ms} = 1 * 10^{11}$  particles in a pulse

Changing the number itself is not a problem, but it changes the “strategy”

# Chopper - Geometry

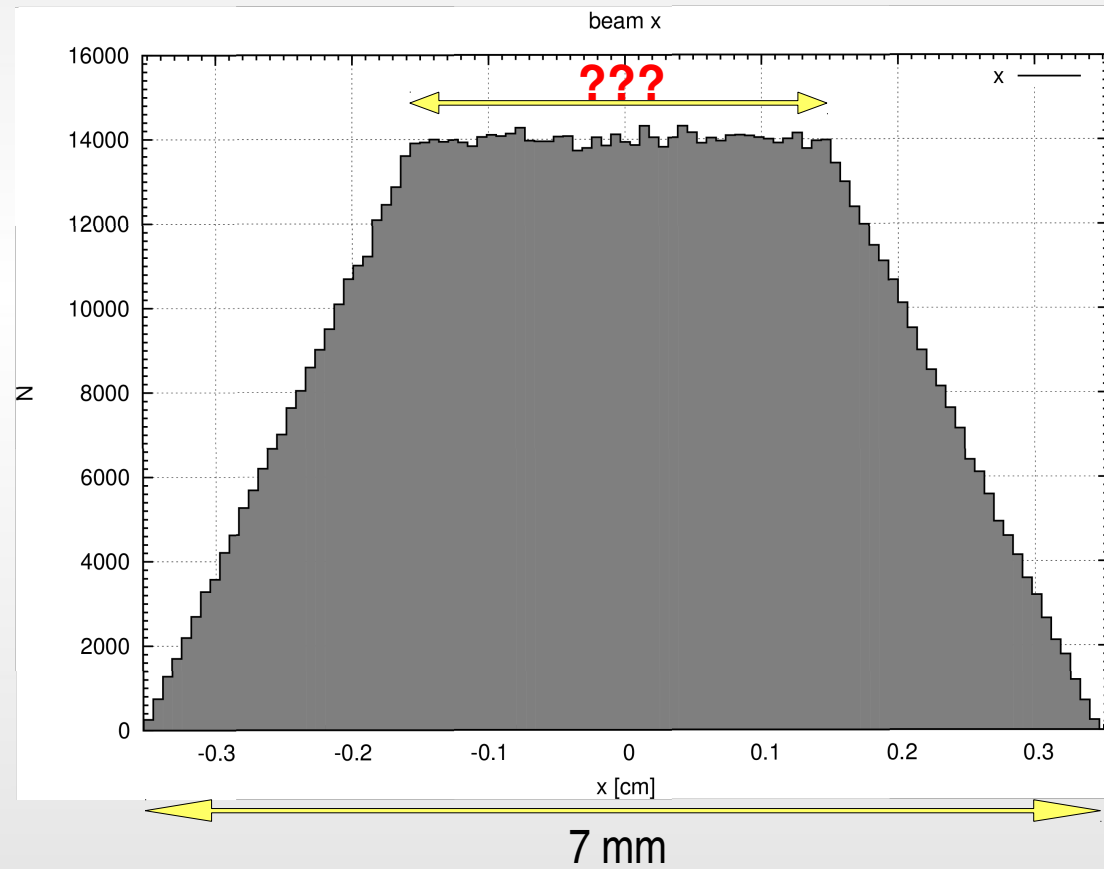
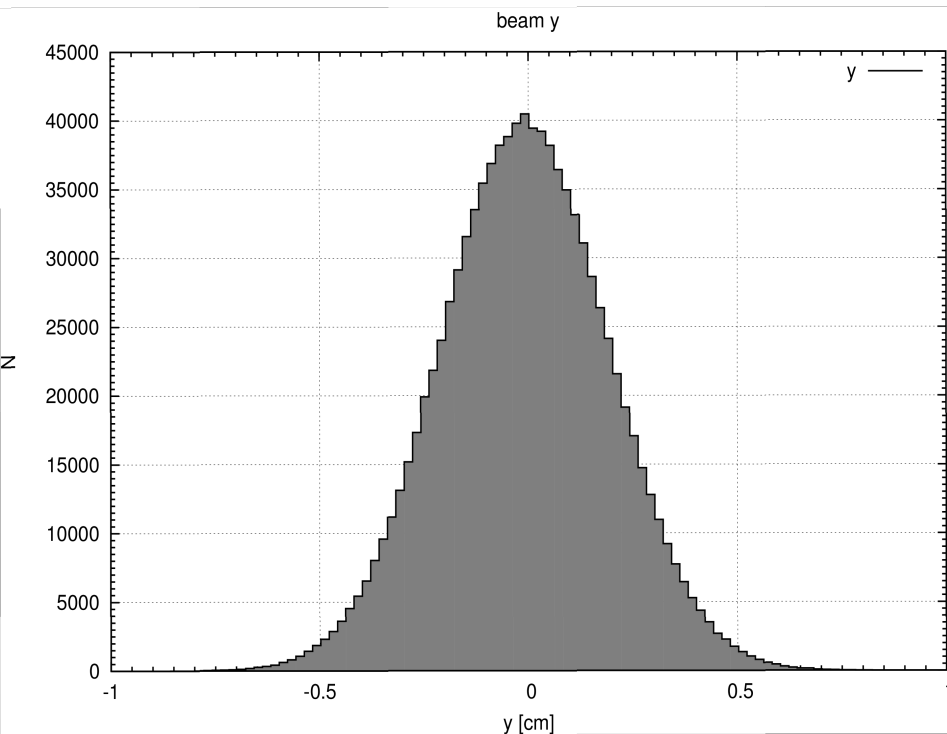
GeoViewer Red plot



- Tungsten block: 6 x 6 x 15 cm
- Carbon insert:  $\varnothing$  15. cm, length 5 cm

# Chopper – Beam profile

- Beam profile
  - Shape: H: trapezoidal, V: Gaussian
  - Total in x = 7 mm
  - $\sigma_y = 2\text{mm}$

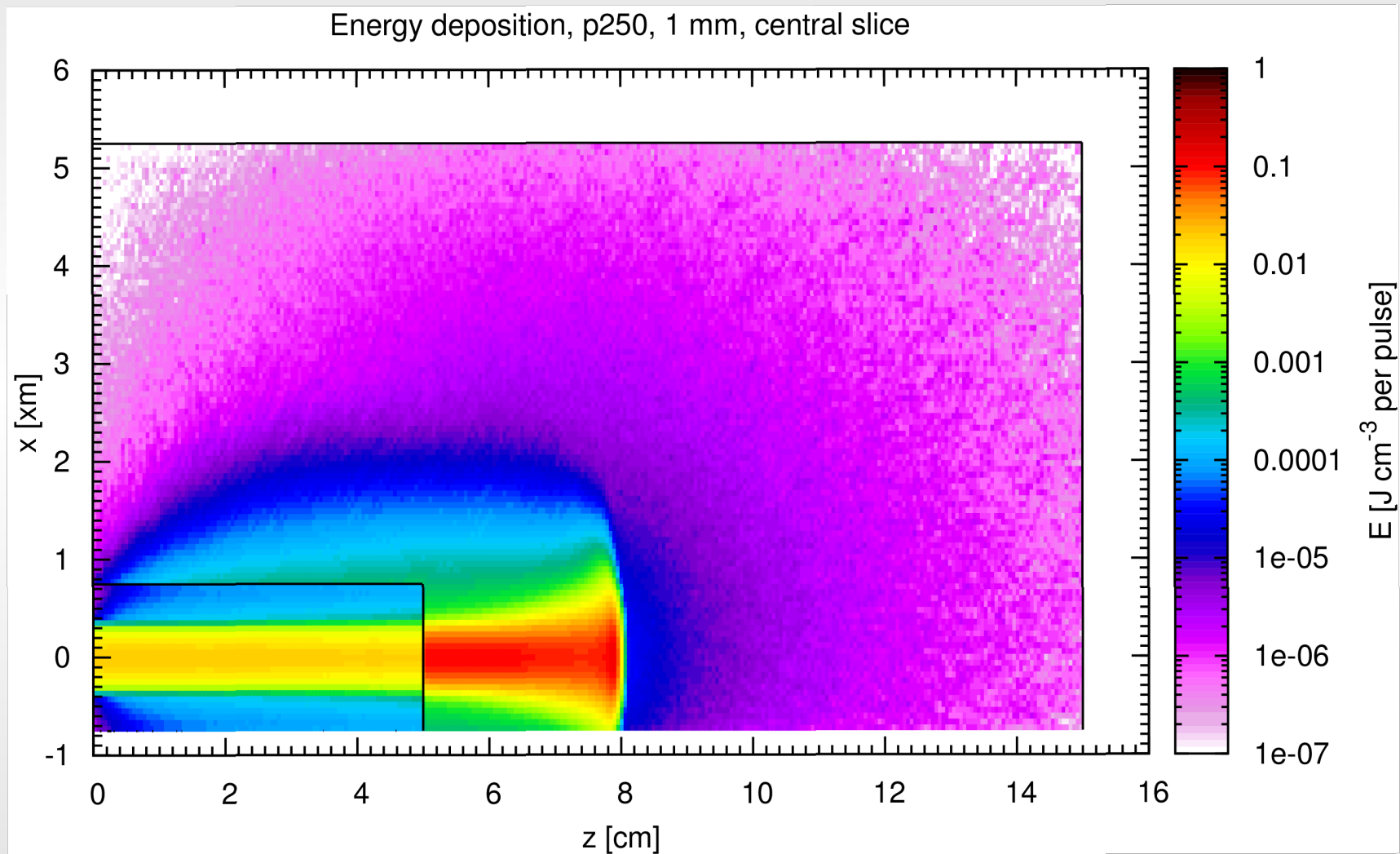


- Two choices for the upper side width: 6 mm and 1 mm

# Chopper – number of particles

- The number of circulating ions in the synchrotron is up to:  
proton:  $3 \cdot 10^{10}$ , Carbon:  $1.5 \cdot 10^9$
- 10 % of each spill impacts the Chopper
  - Protons:  $3 \cdot 10^9$
  - Carbon ions:  $1.5 \cdot 10^8$
- Beam energy:
  - Protons 250 MeV
  - C ions 400MeV/u

# Energy deposition, p 250 MeV, 1mm upper edge



# Energy deposition, p 250 MeV, 1mm upper edge

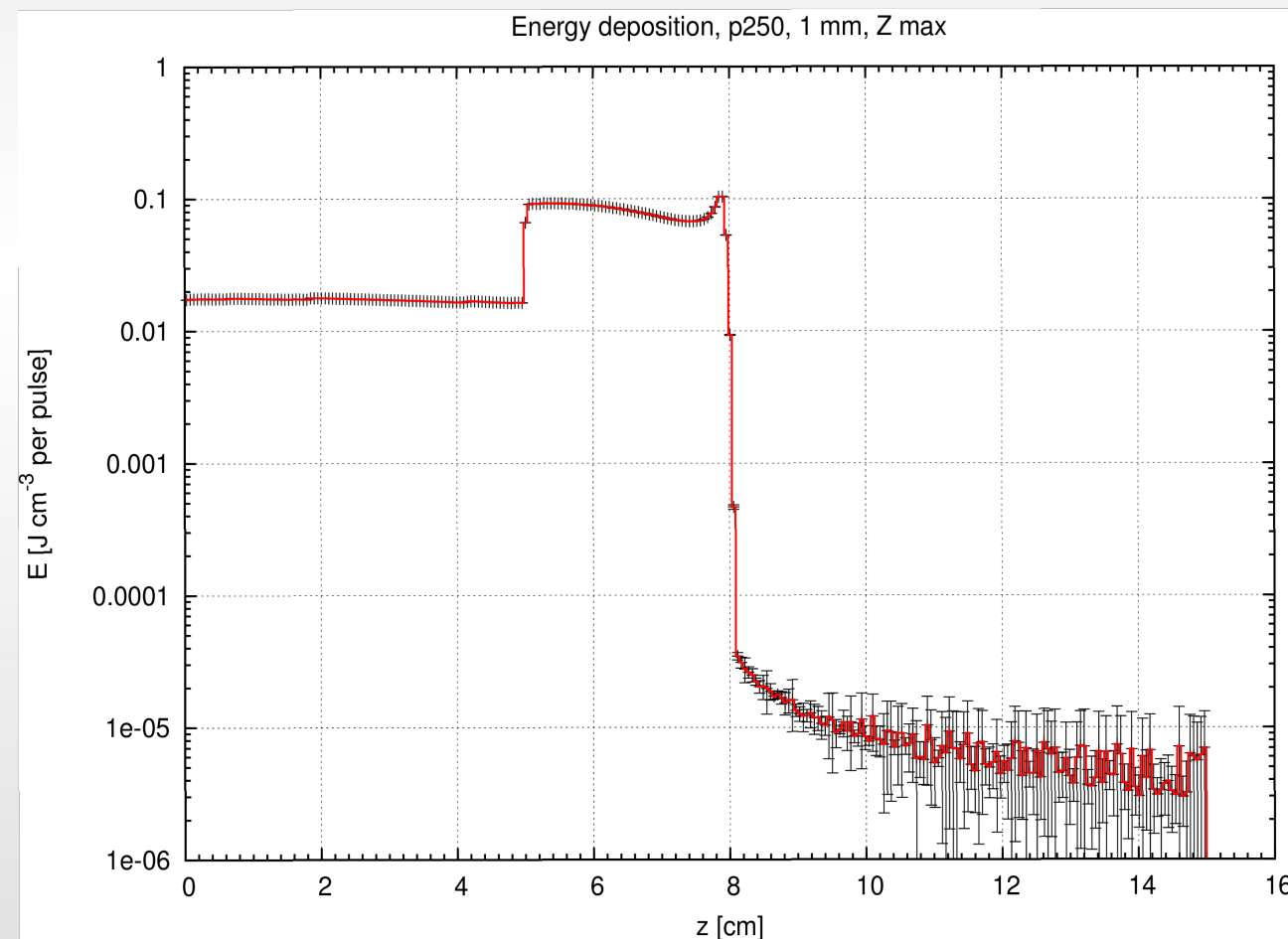
- Maximum Energy deposition:

– In carbon:

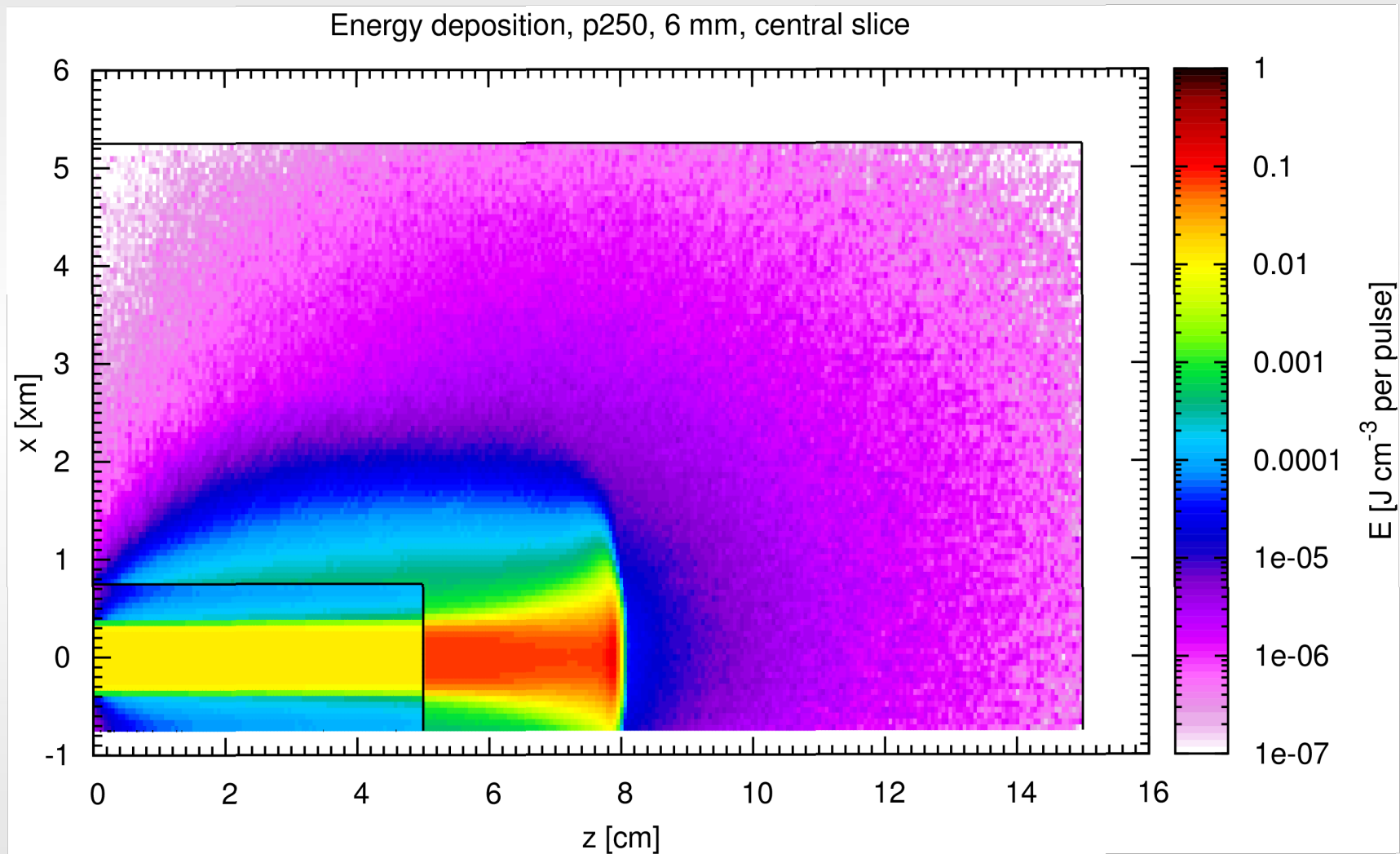
17.4 mJ cm<sup>-3</sup> per pulse

– In tungsten:

0.1 J cm<sup>-3</sup> per pulse



# Energy deposition, p 250 MeV, 6mm upper edge



# Energy deposition, p 250 MeV, 6mm upper edge

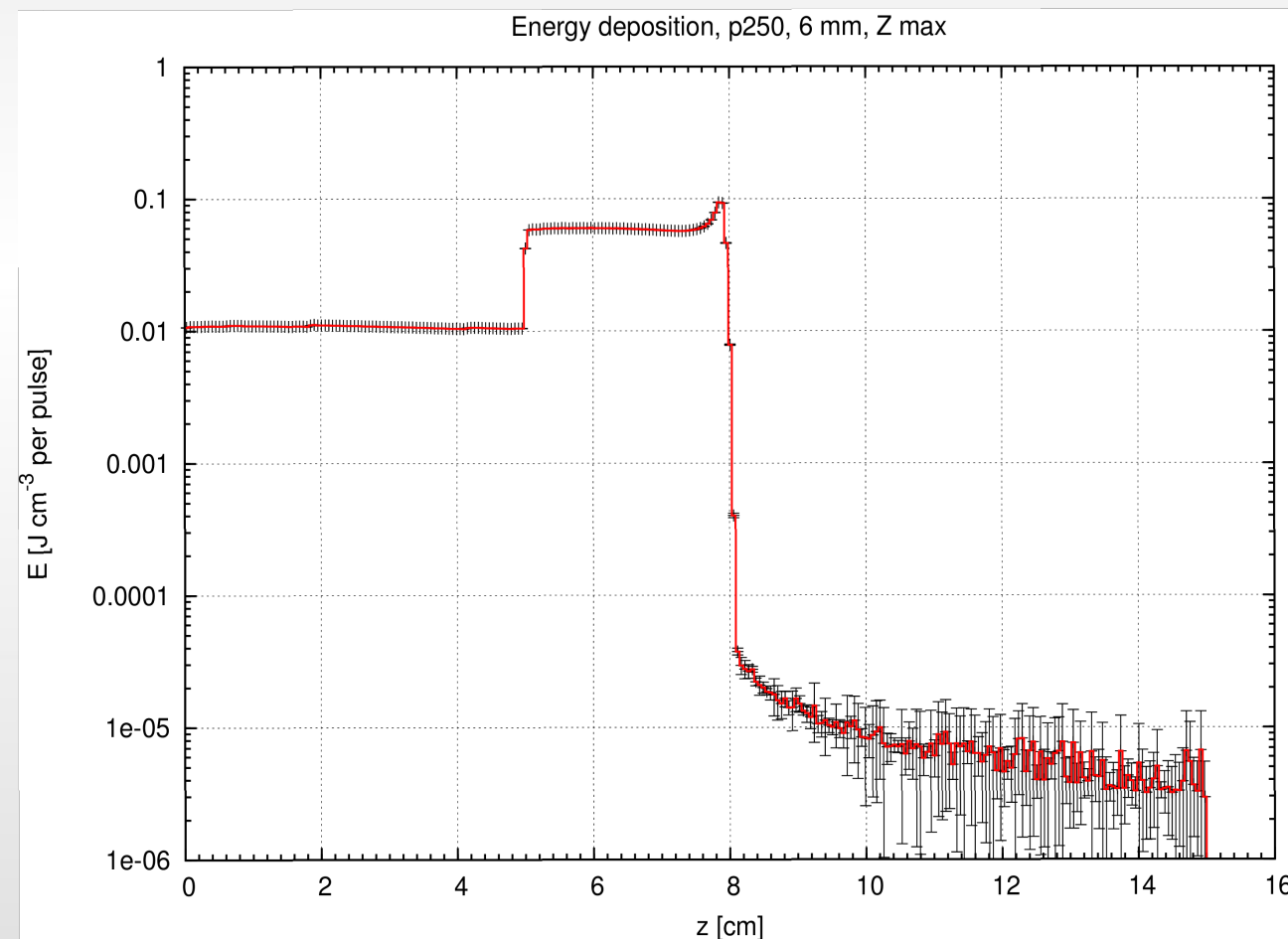
- Maximum Energy deposition:

– In carbon:

$10 \text{ mJ cm}^{-3}$  per pulse

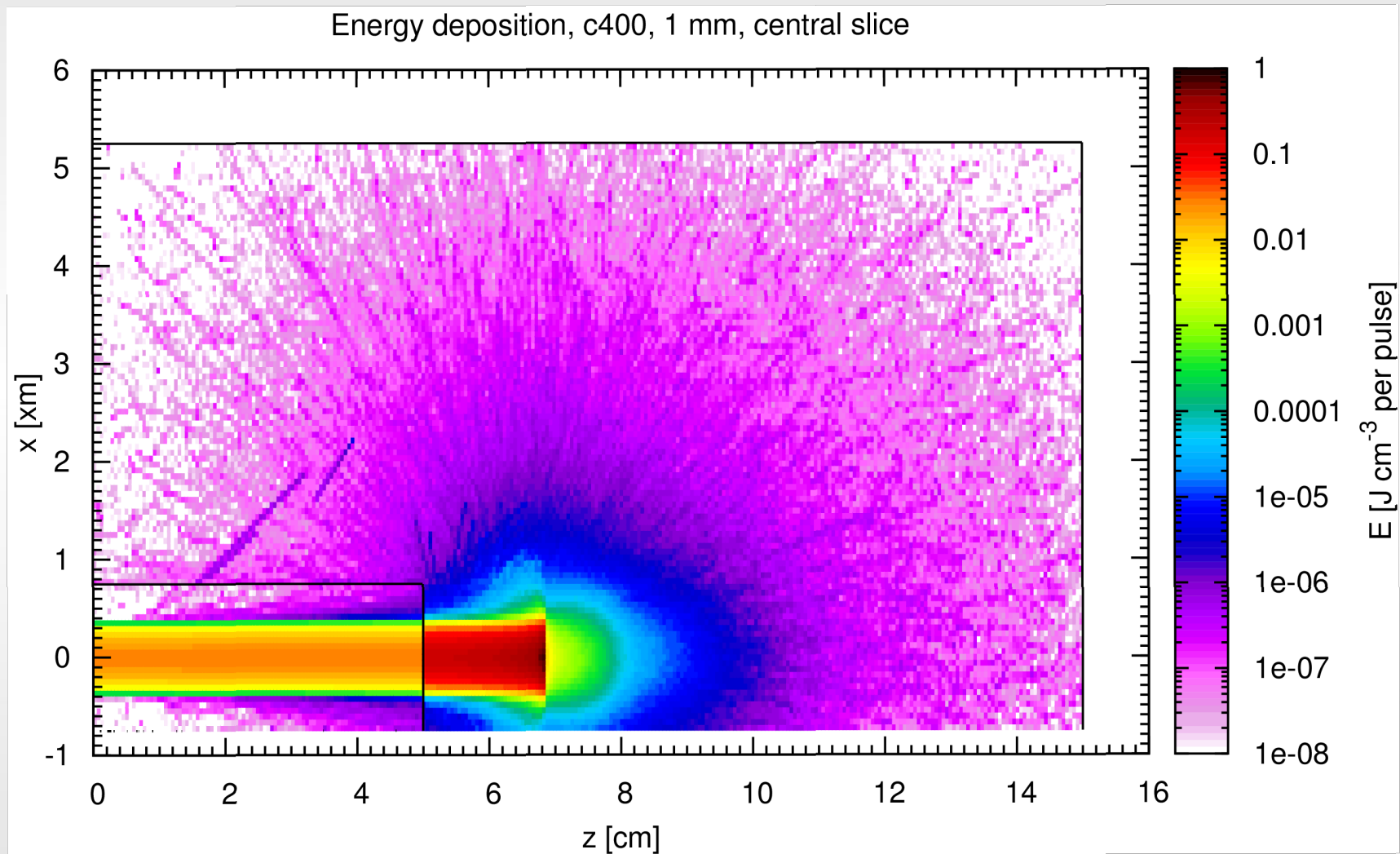
– In tungsten:

$0.1 \text{ J cm}^{-3}$  per pulse





# Energy deposition, C 400 MeV, 1mm upper edge



# Energy deposition, C 400 MeV, 1mm upper edge

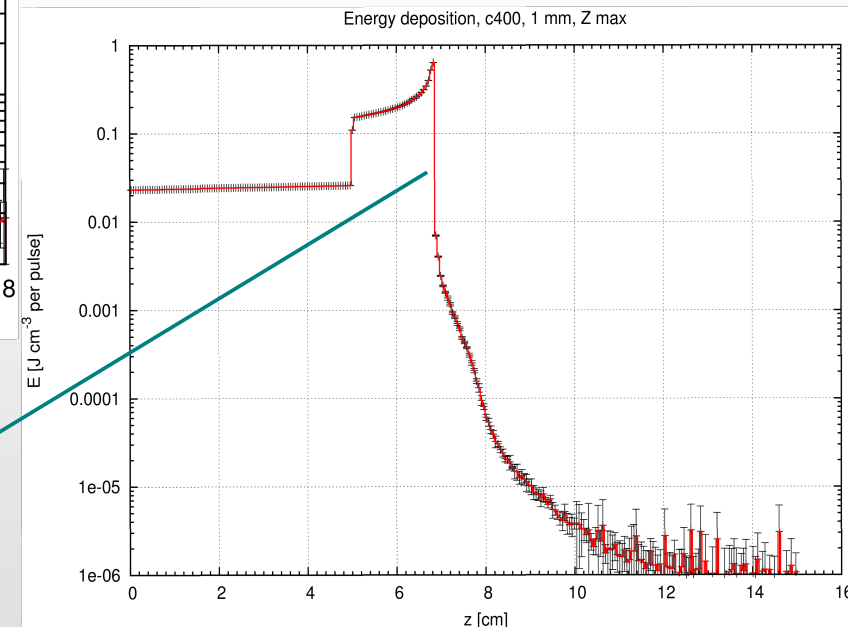
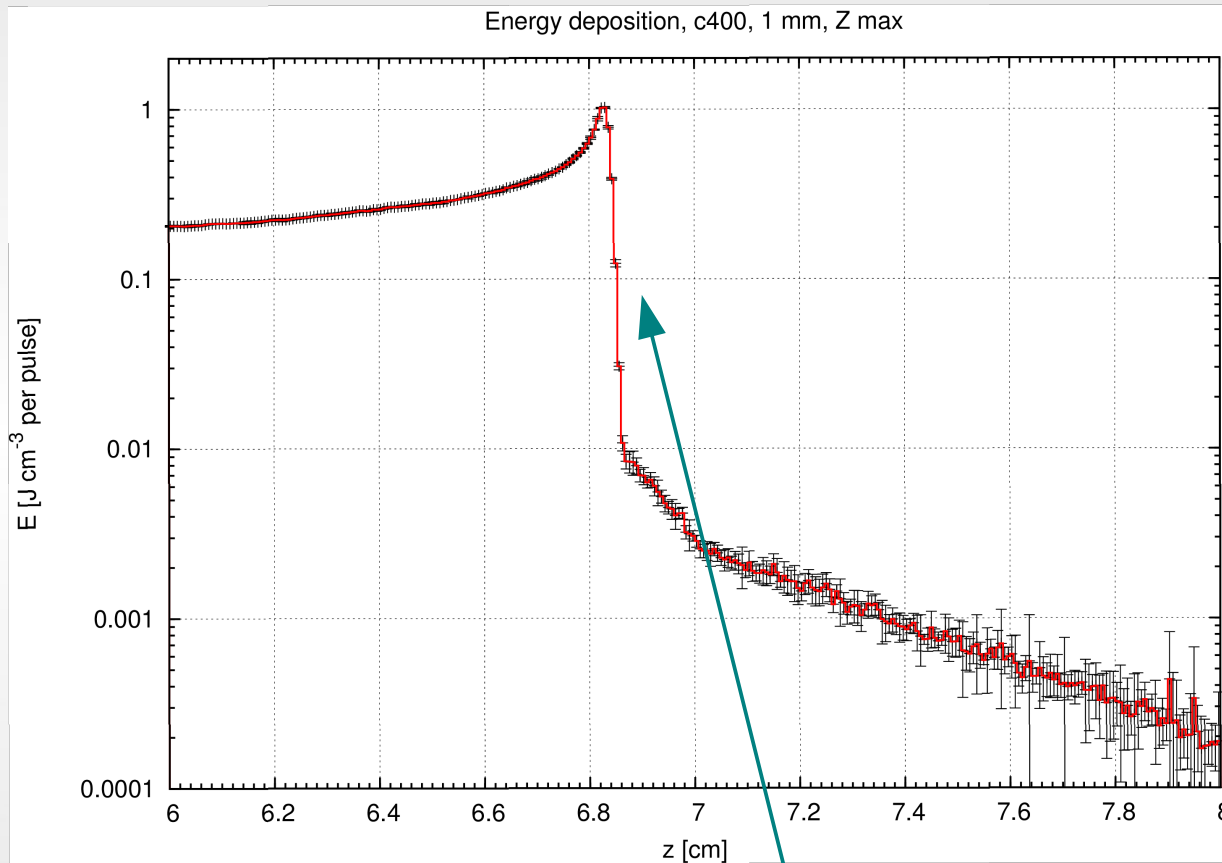
- Maximum Energy deposition:

– In carbon:

26 mJ cm<sup>-3</sup> per pulse

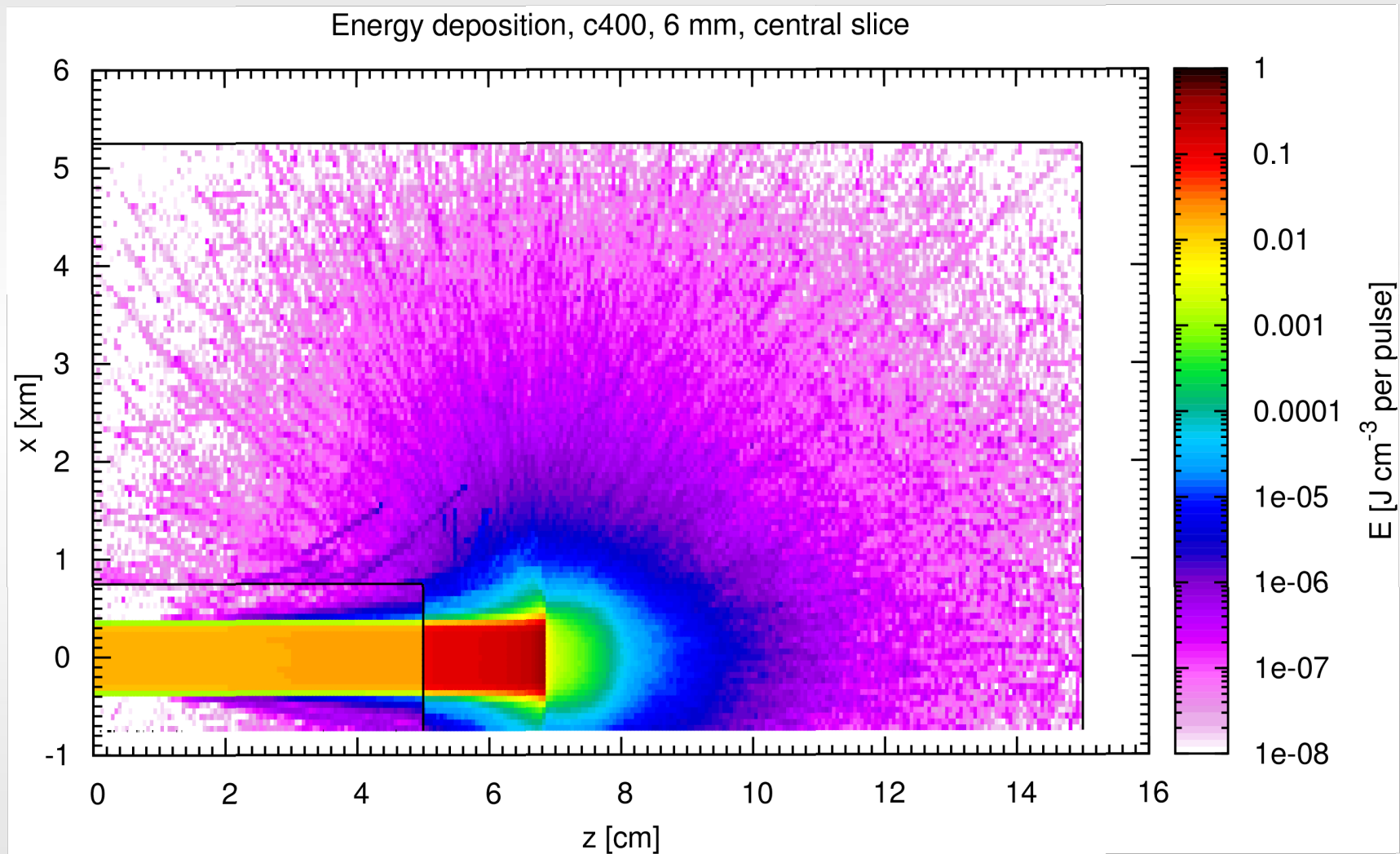
– In tungsten:

1.0 J cm<sup>-3</sup> per pulse



Very sharp fall, finer mesh is needed

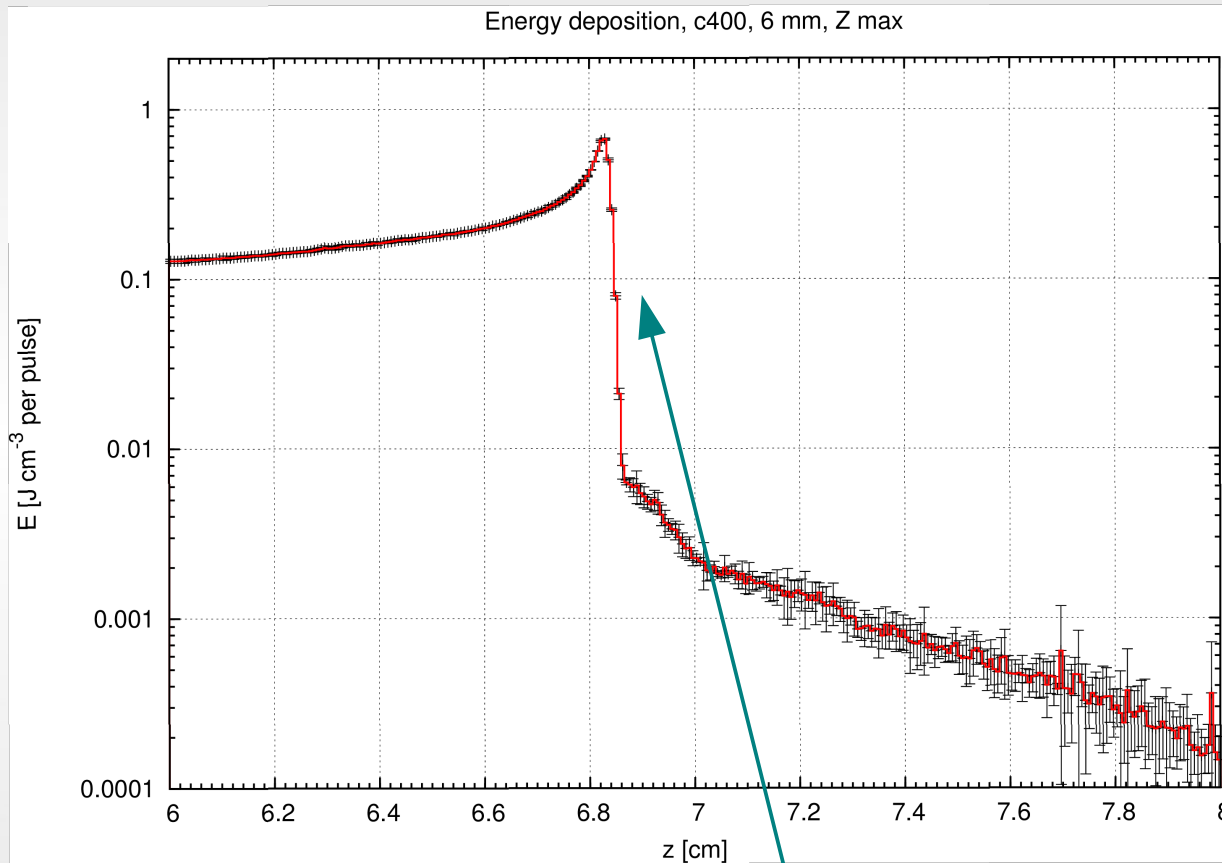
# Energy deposition, C 400 MeV, 6mm upper edge



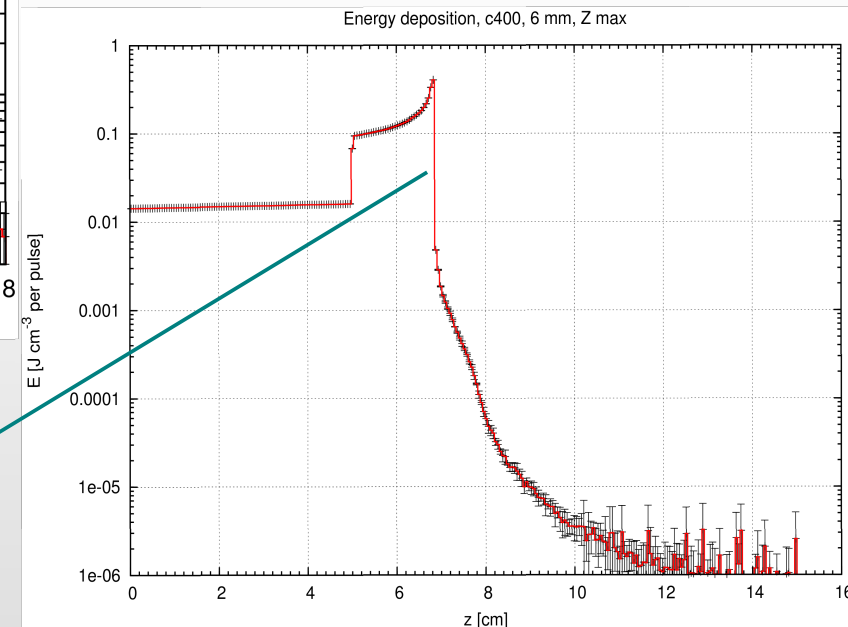
# Energy deposition, C 400 MeV, 1mm upper edge

- Maximum Energy deposition:

- In carbon:  
 $16 \text{ mJ cm}^{-3}$  per pulse
- In tungsten:  
 $0.69 \text{ J cm}^{-3}$  per pulse



Very sharp fall, finer mesh is needed



# Chopper - Conclusions

Maximum energy deposition densities in  $\text{J cm}^{-3}$  per pulse

	p250; 1mm	P250; 6mm	C400; 1mm	C400; 6mm
Carbon	0.017	0.01	0.026	0.016
Tungsten	0.1	0.1	1.0	0.69