MARS15 RESULTS FOR THE LBNE-BLIP IRRADIATION TEST

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LBNE-BLIP Irradiation Test Meeting
Fermilab
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Outline

- Fall 2009 Conclusions in 3 slides
- New Sample Geometry and Beam in MARS15
- Power Density, DPA, Gas Production and Activation
- Summary

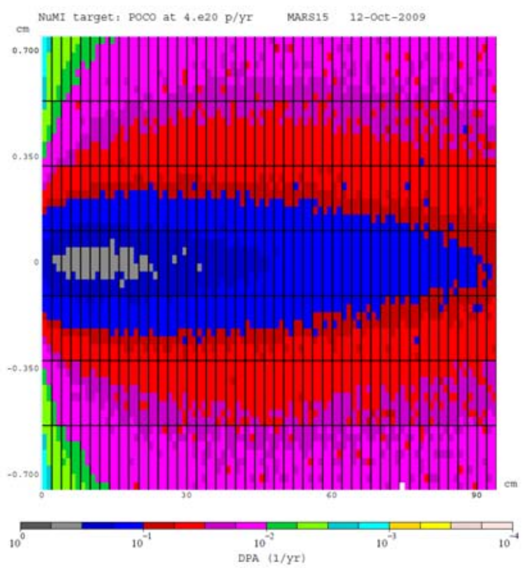
NuMI Target

120-GeV proton beam
$\sigma_x = \sigma_y = 1.1$ mm

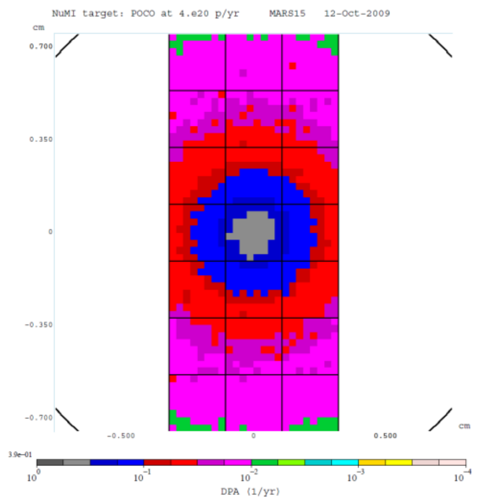
2e13 p/s × 2e7 s/yr = 4e20 p/yr

Target: POCO Graphite, 1.78 gcc
47 × (15 × 6.4 × 20 mm)

Peak: 0.45 DPA/yr, 123 W/g



Y=±1 mm



z= 15 cm

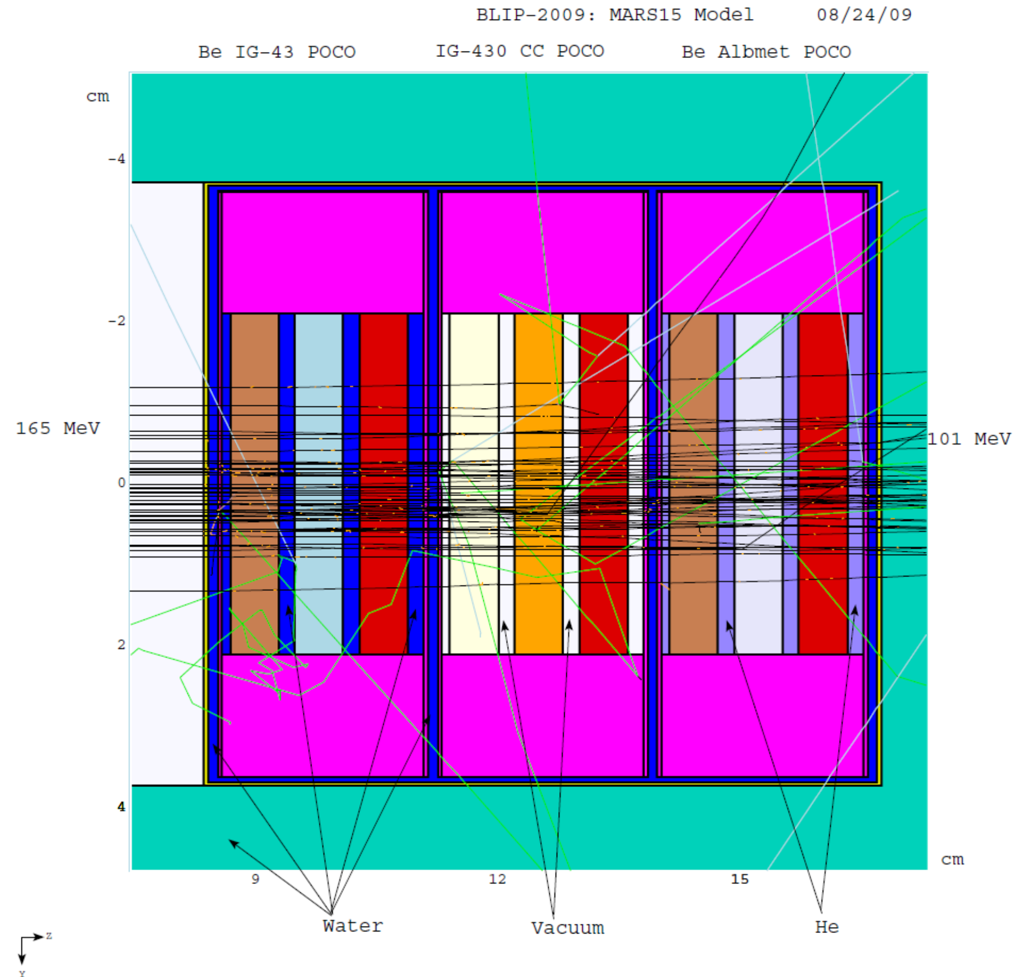
BLIP Target (2009)

165-MeV proton beam
to get 101 MeV downstream
$\sigma_x = \sigma_y = 4.233$ mm

90μA: 5.62e14 p/s × 2e7 s/yr
= 1.124e22 p/yr

Nine 6-mm thick samples, 3 per box

Box-1: Be + IG-43 + POCO (Water)
Box-2: IG-430 + CC + POCO (Vacuum)
Box-3: Be + Albmet +POCO (He)



Peaks in POCO graphite (3d sample in each box):
1.37, 1.41 and 1.55 DPA/yr, respectively,
or <u>0.37, 0.38 and 0.42 DPA in 9 weeks (~1 LBNE year at 700 kW)</u>.
Peak power density is ~400 W/g.

DPA Composition and BLIP for NuMI/LBNE (2009)

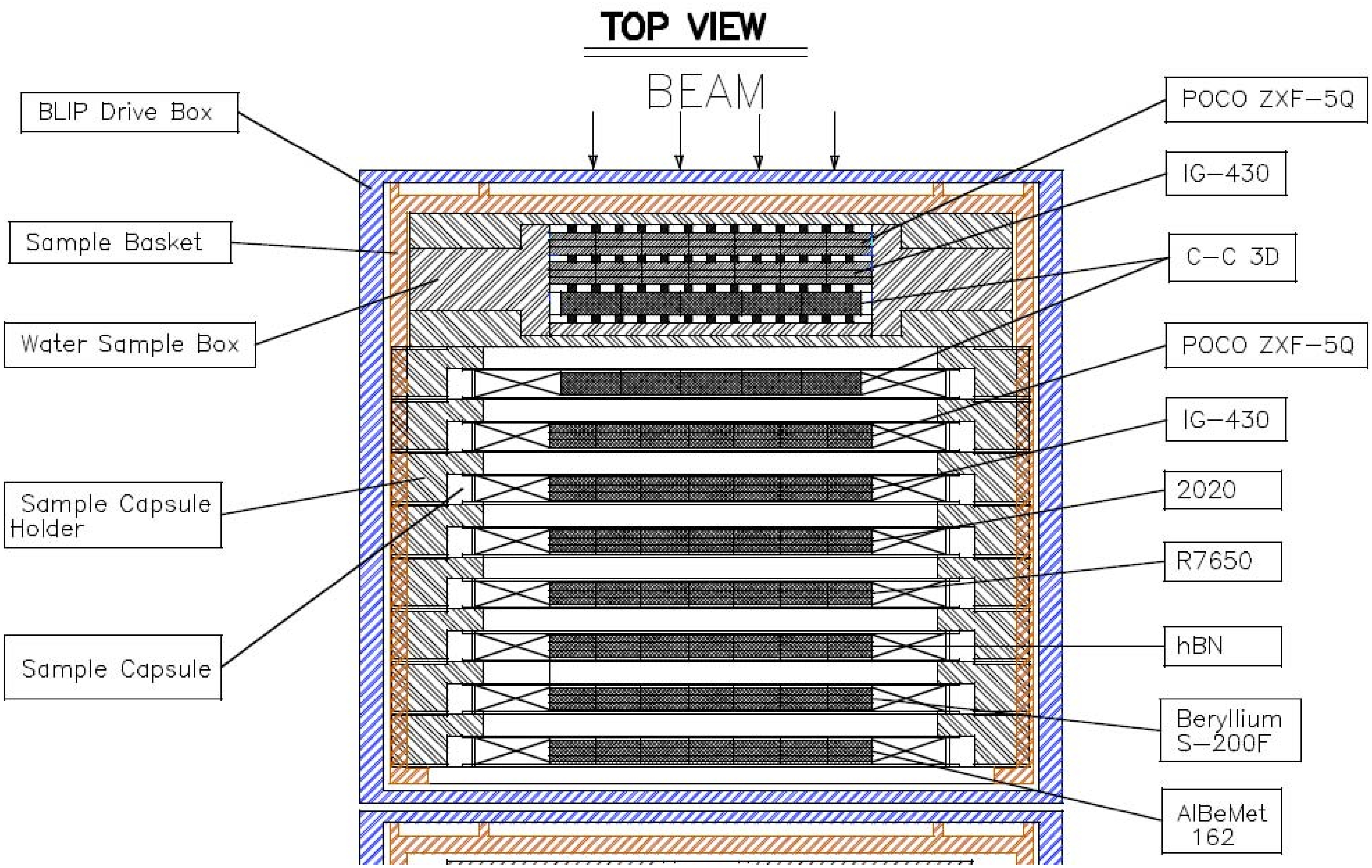
Physics process contribution (%) at beam axis:
z=15 cm (NuMI) and Box 2 POCO graphite (BLIP)

Target	Nuclear	EM elastic	L.E. neutrons	$e^{\pm}$
NuMI	50.8	43.3	1.5	4.4
BLIP	43.5	53	3.5	0.02

Target	E_p (GeV)	Beam σ (mm)	N_p (1/yr)	DPA (1/yr)
NuMI/LBNE	120	1.1	4.0e20	0.45
BLIP	0.165	4.23	1.124e22	1.5

Earlier obtained 0.2-DPA damage limit for carbon materials of interest for 0.7-MW LBNE can be achieved at BLIP over 7 weeks

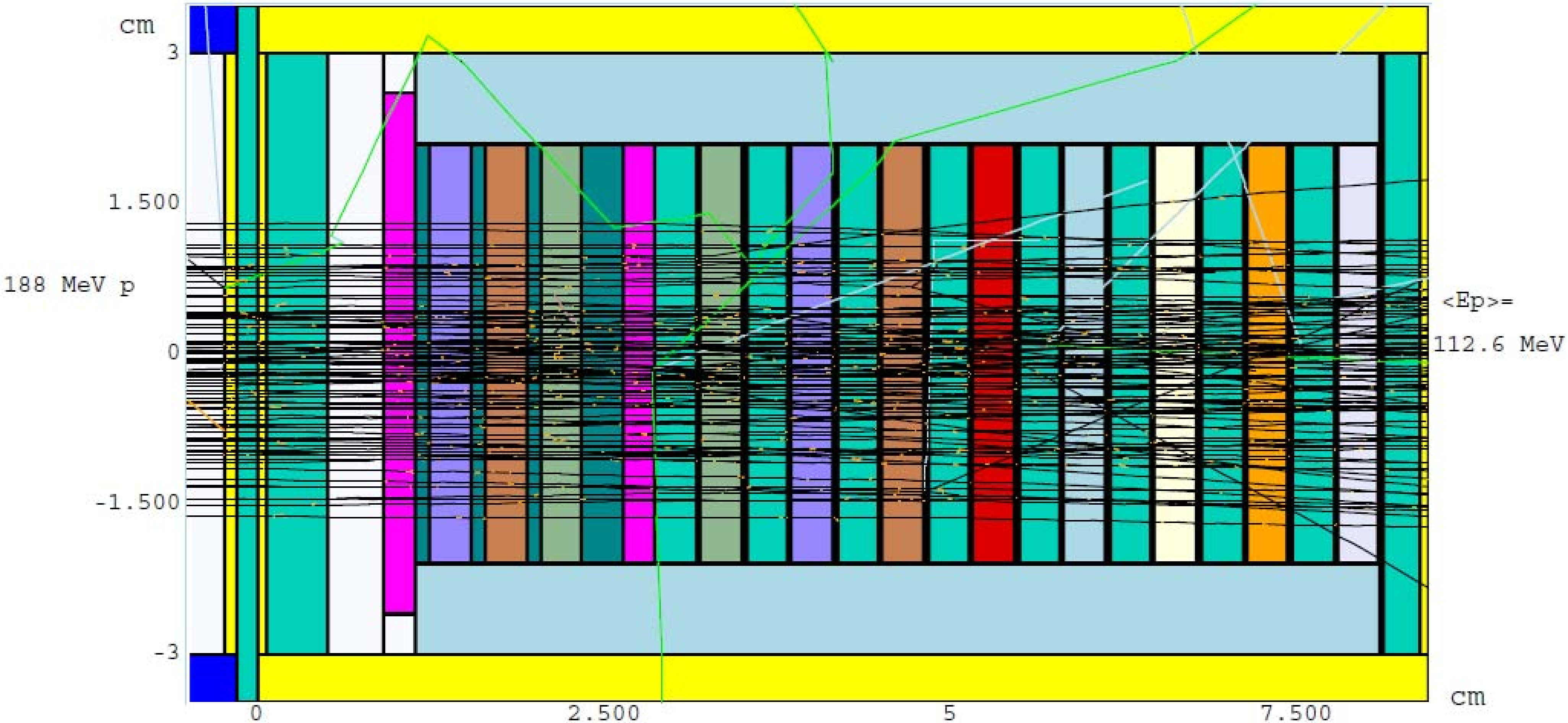
Sample Geometry and Beam (February 2010)



Eleven 3-mm thick samples in water

Exit proton beam energy needed = 112.65 MeV,
σ_x = 8.92 mm, σ_y = 6.79 mm
94μA: 5.87e14 p/s
9 weeks = 63 days = 5.44e6 s

MARS15 Modeling (1)



MARS15 Modeling (2)

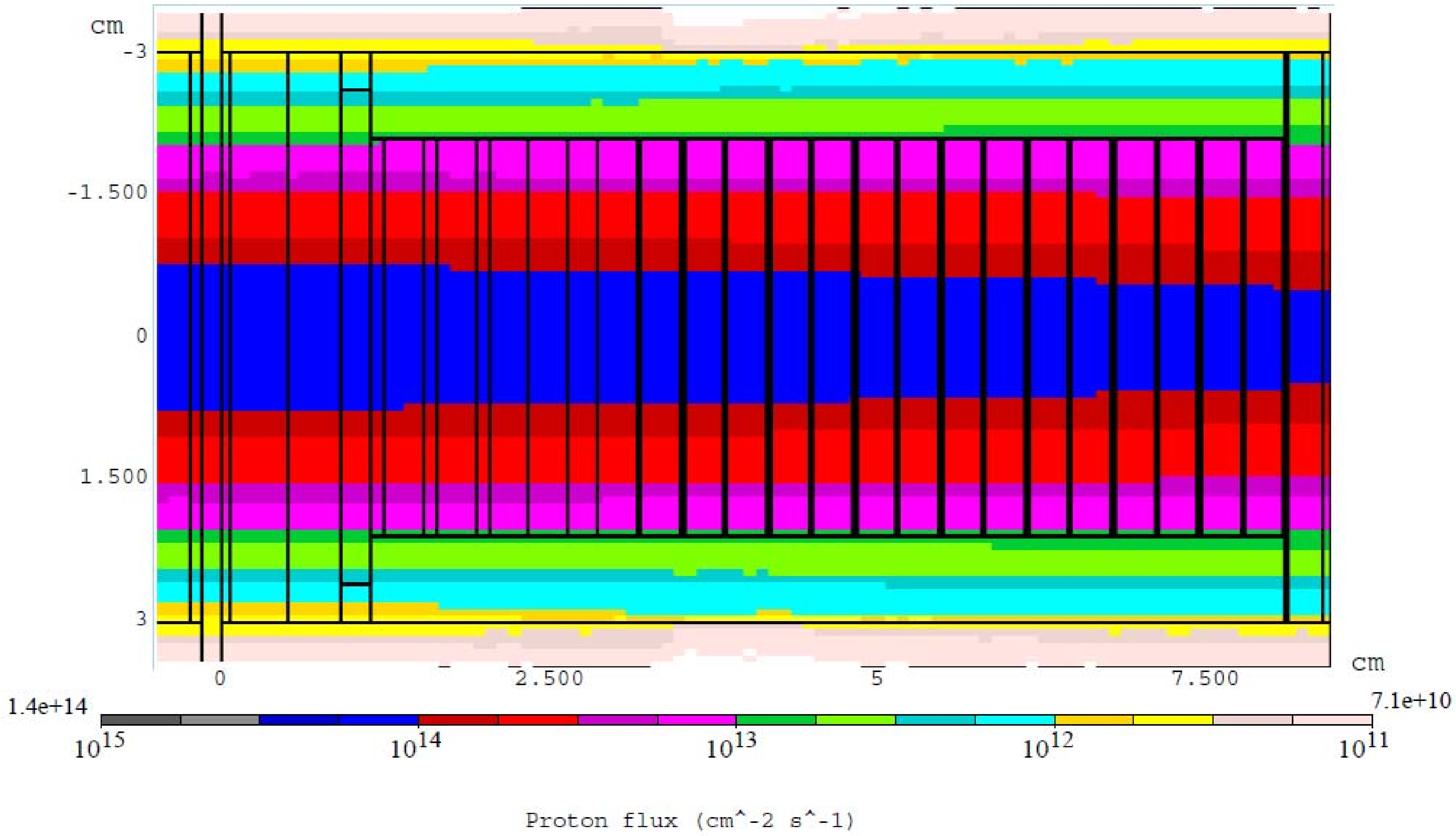
Proton beam energy from Linac needed = 188 MeV

Calculated: particle fluxes, power density, DPA, hydrogen and helium gas production and residual dose two-dimensional distributions along and across the beam

All values are inversely proportional to the beam area, therefore **expected reduction** is

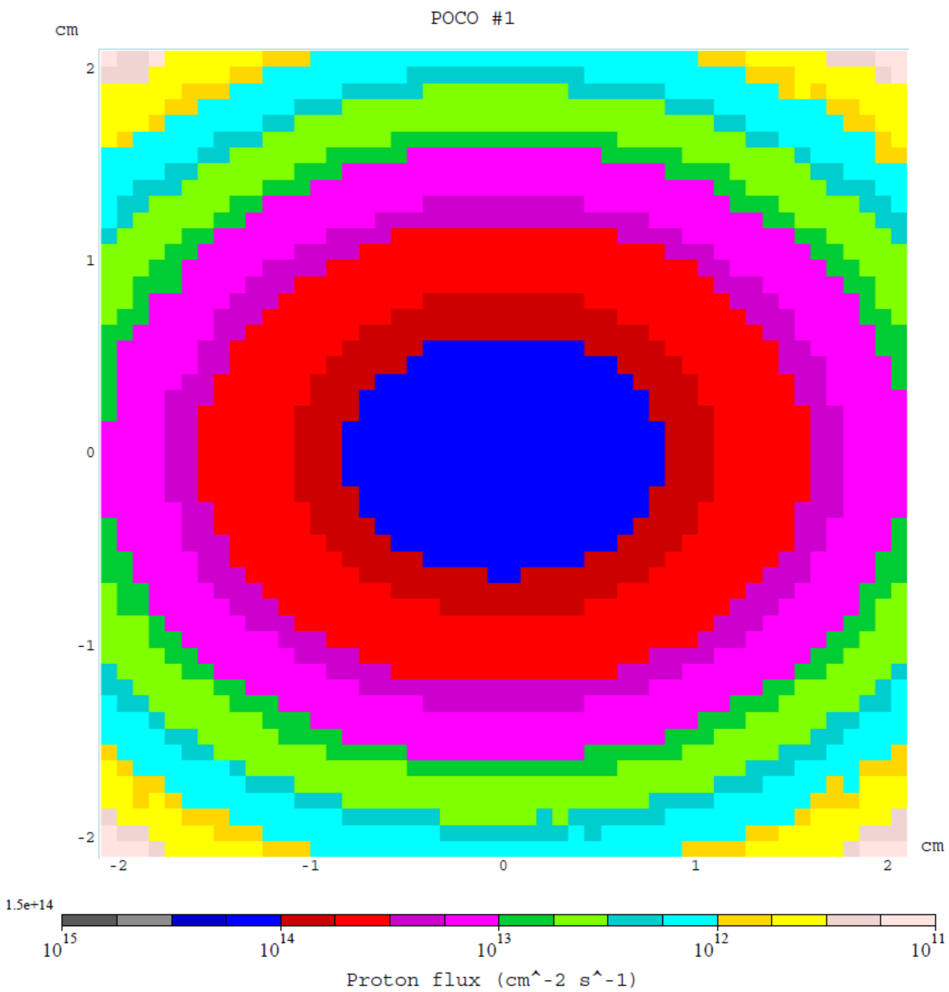
$$4.233^2/(8.92*6.79) \sim \mathbf{0.3}$$

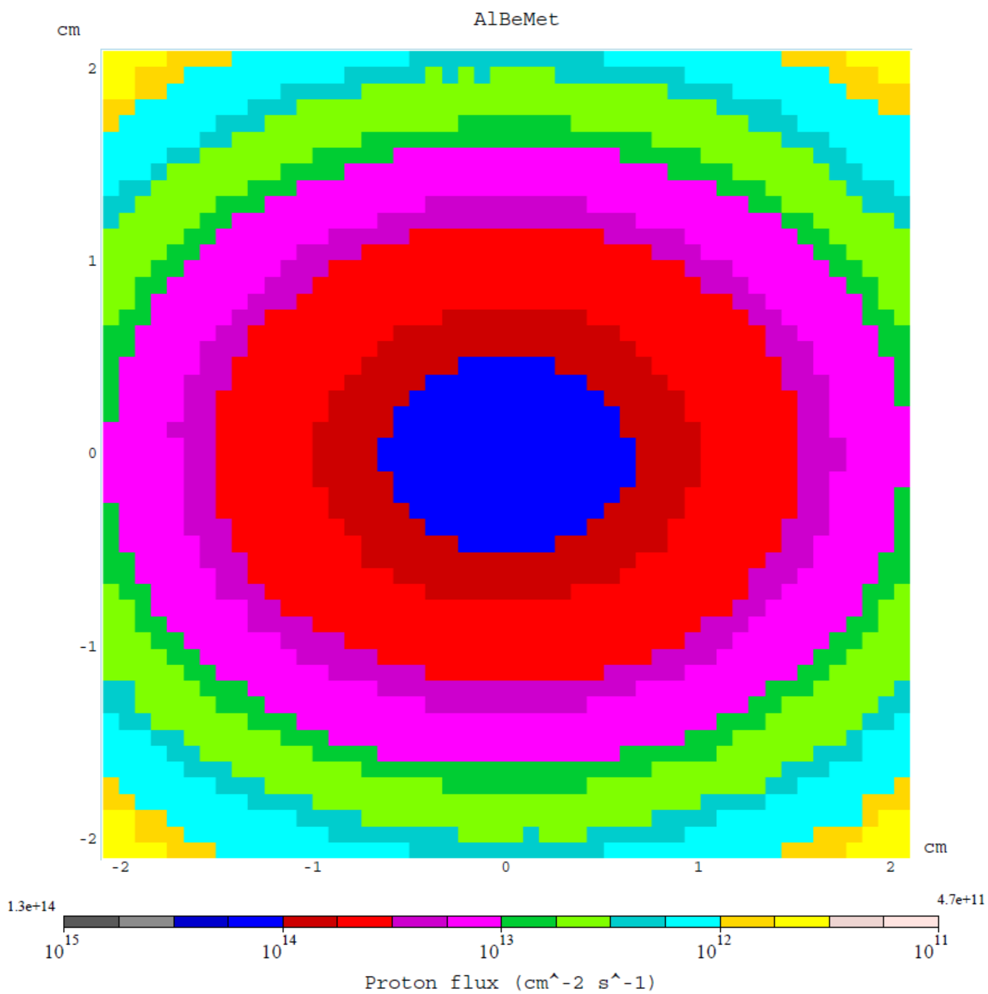
Proton Flux



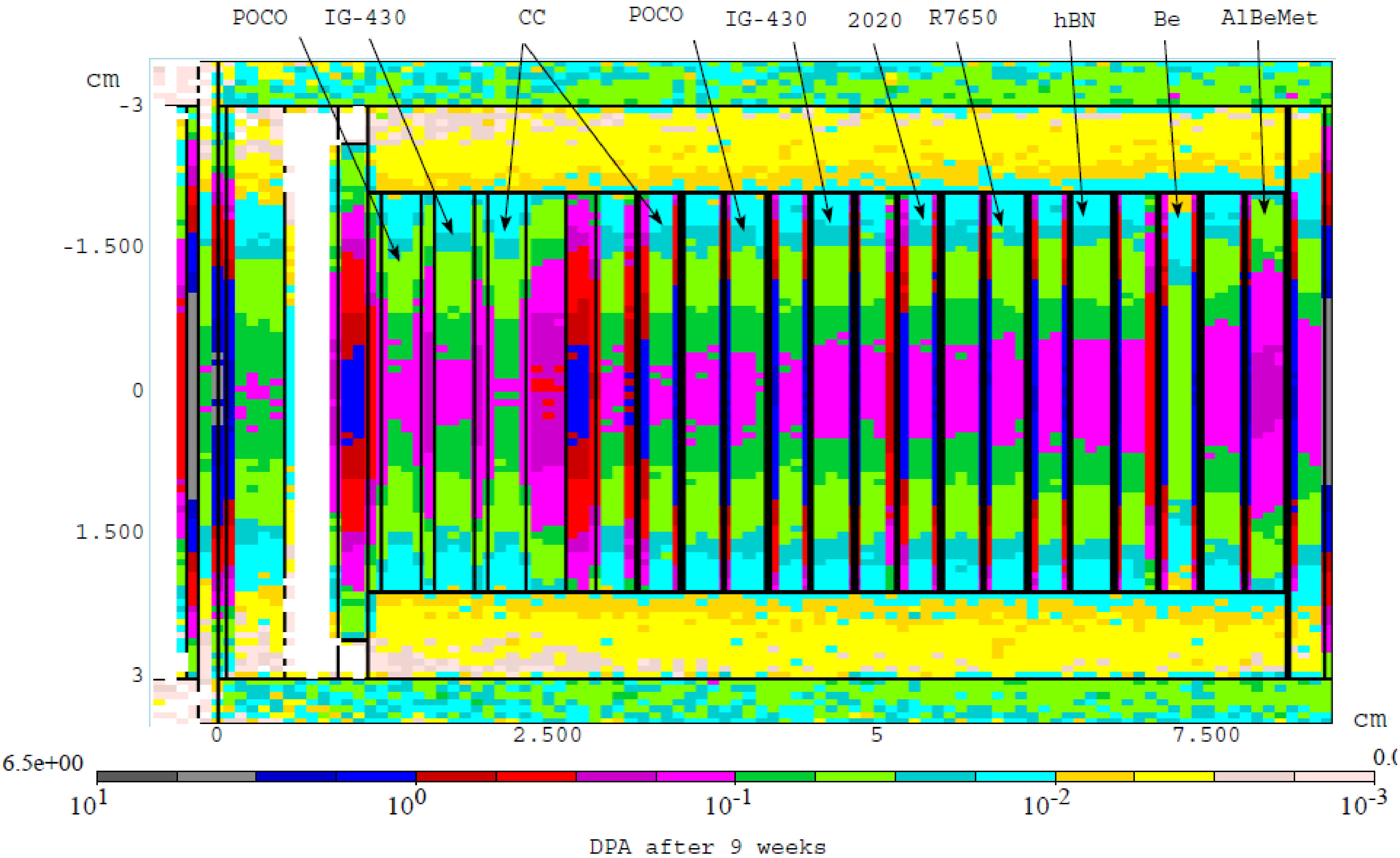
cm
-3
-1.500
0
1.500
3
0
2.500
5
7.500
cm
1.4e+14
7.1e+10
10^{15}
10^{14}
10^{13}
10^{12}
10^{11}
Proton flux (cm^-2 s^-1)

Proton Flux in 1st (POCO) and 11th (AlBeMet) Samples



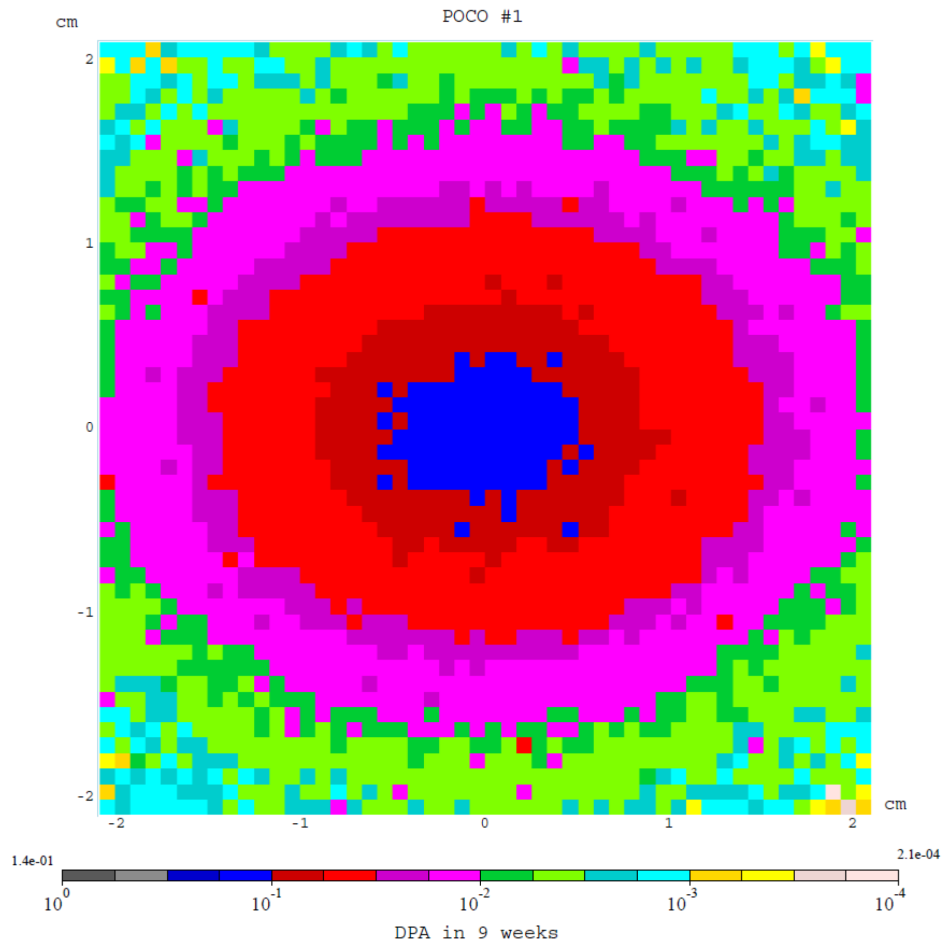


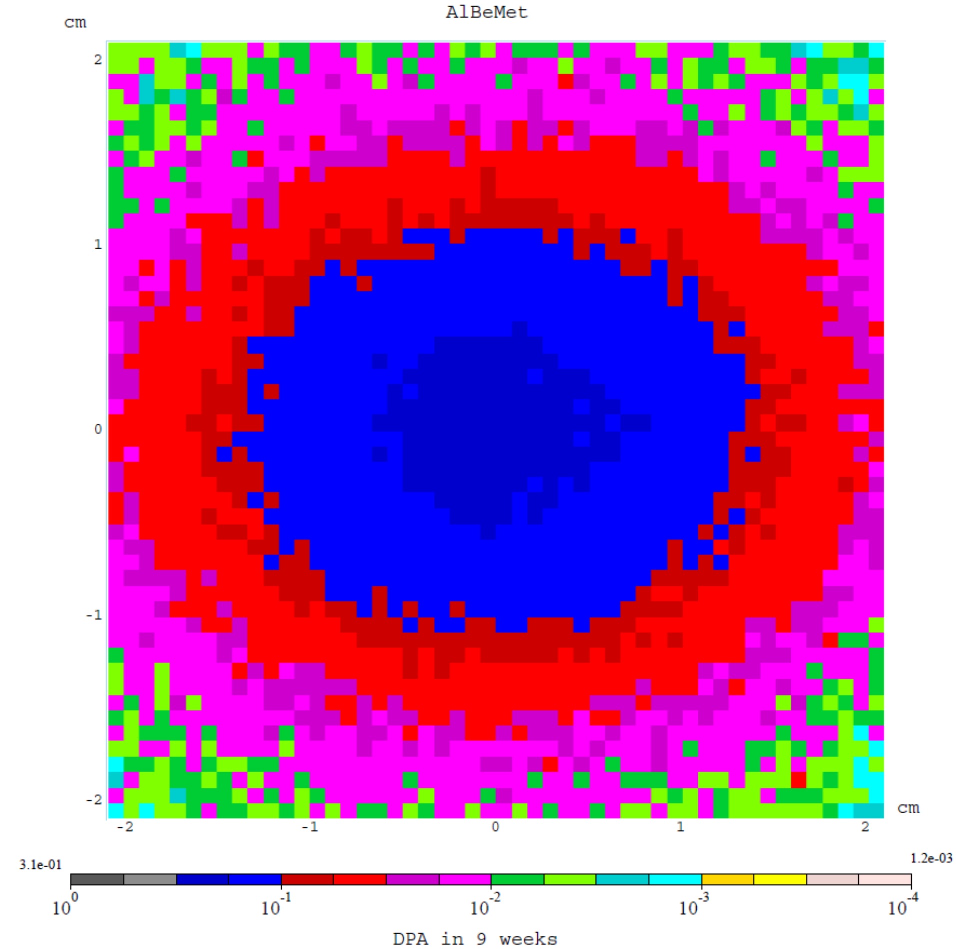
DPA in 9 Weeks



DPA in 1st (POCO) and 11th (AlBeMet) Samples

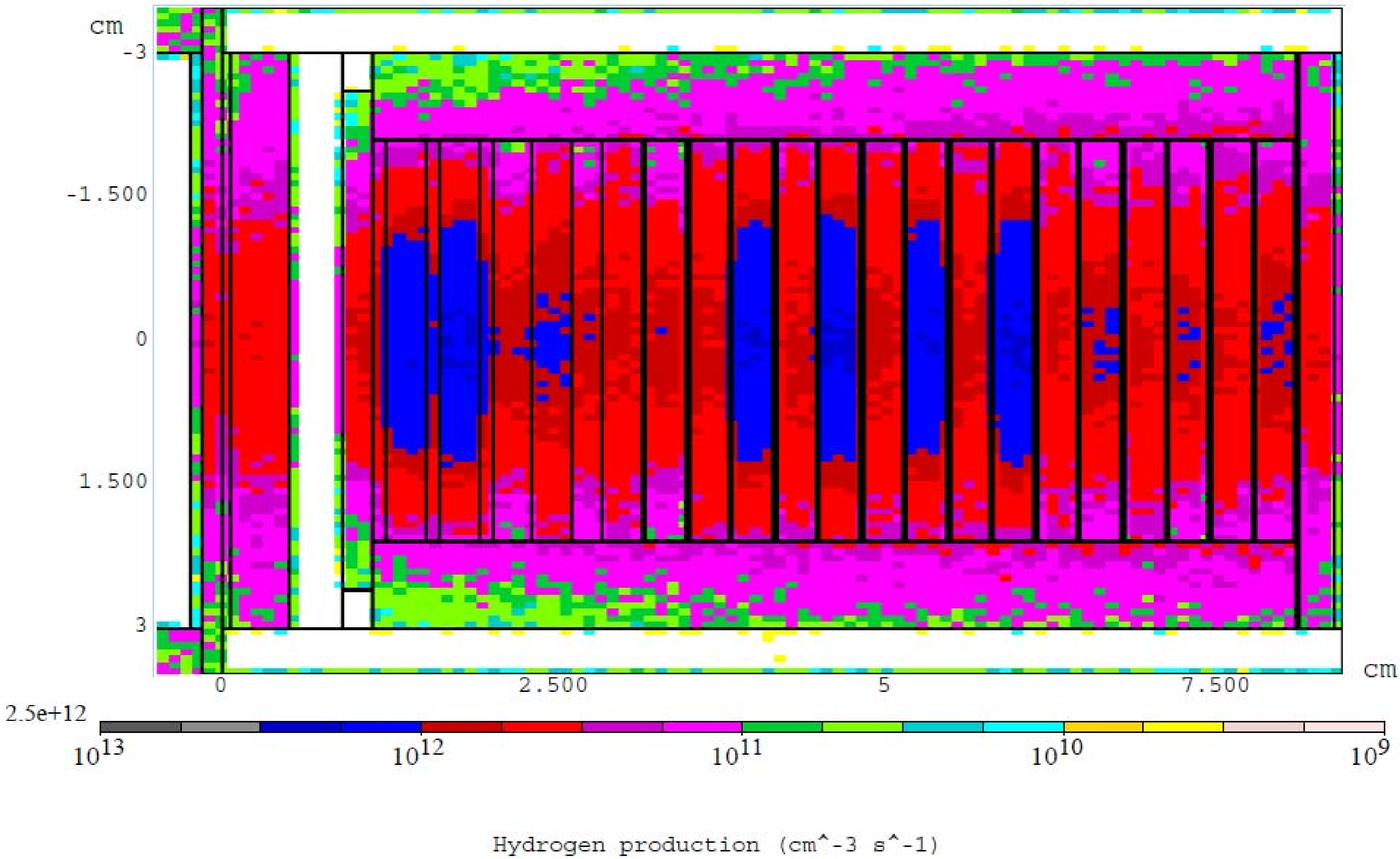
In 9 weeks



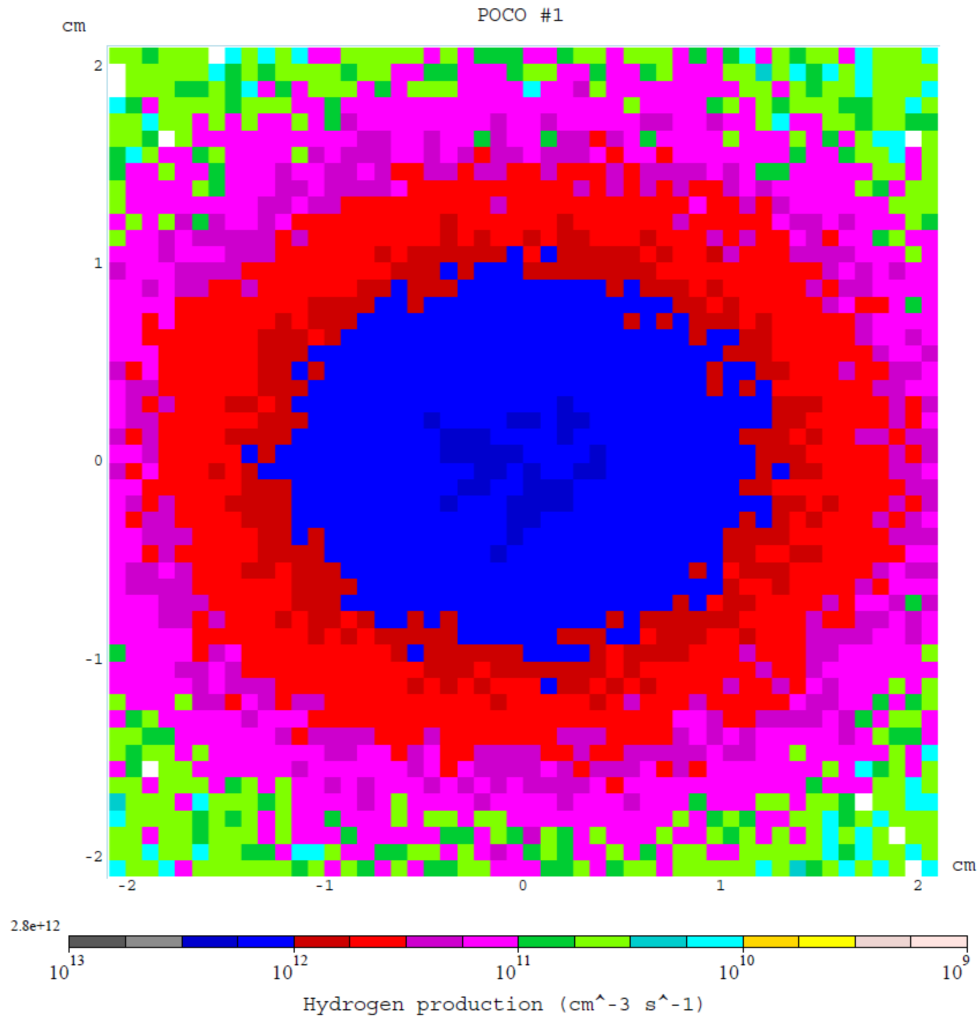


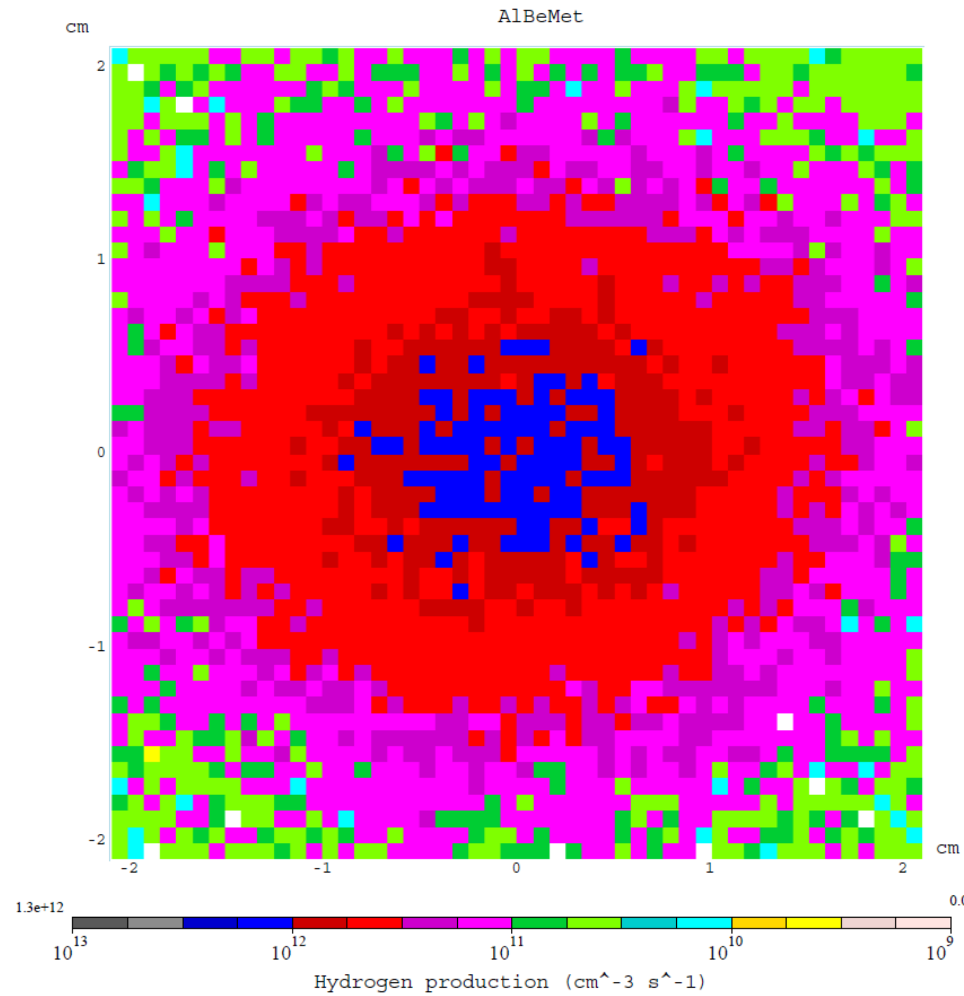
Peak: 0.11-0.13 DPA in 1st to 8th graphite sample, 0.13 DPA in hBN, 0.06 DPA in Be, and 0.3 DPA in AlBeMet

Hydrogen Gas Production



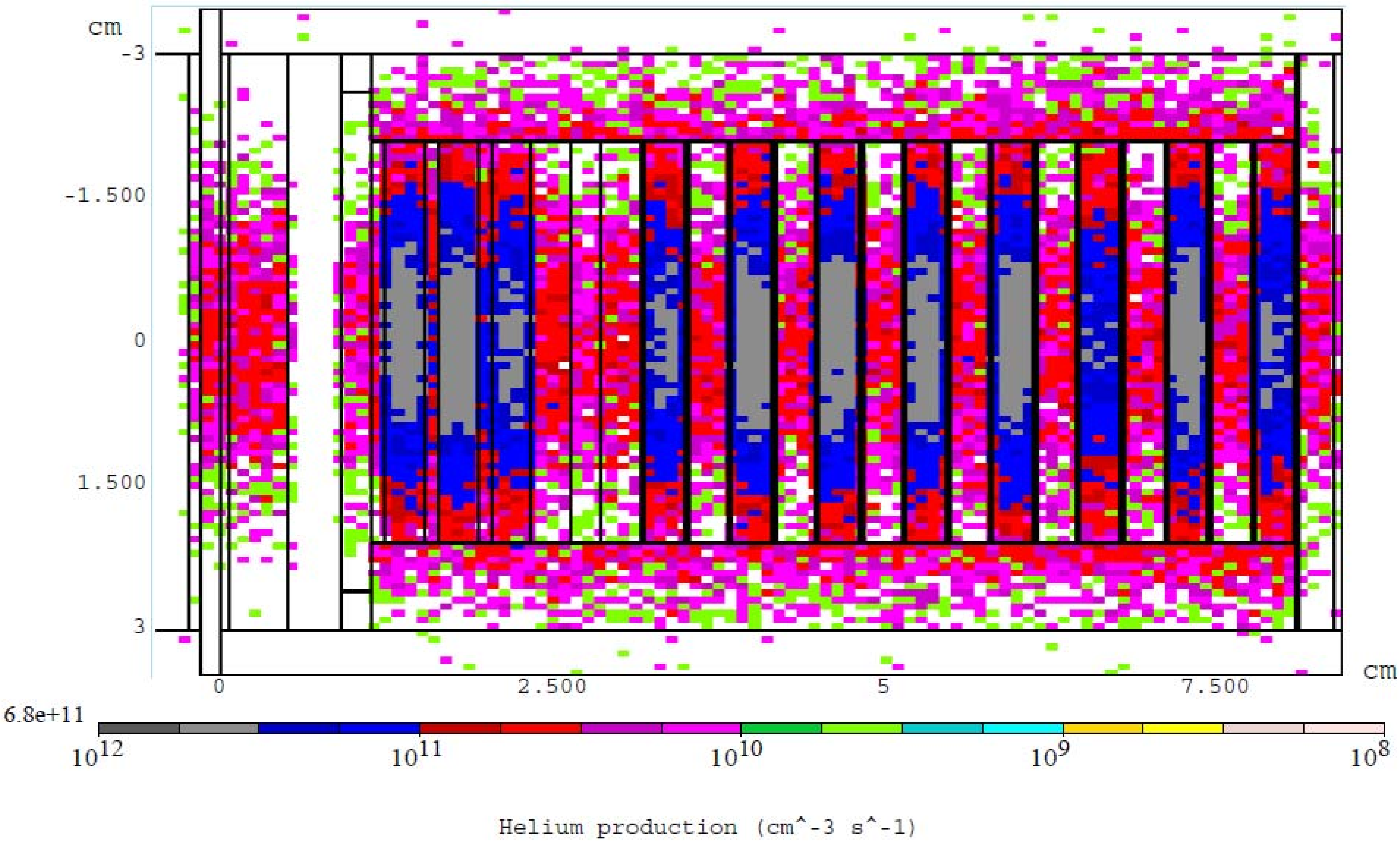
Hydrogen in 1st (POCO) and 11th (AlBeMet) Samples



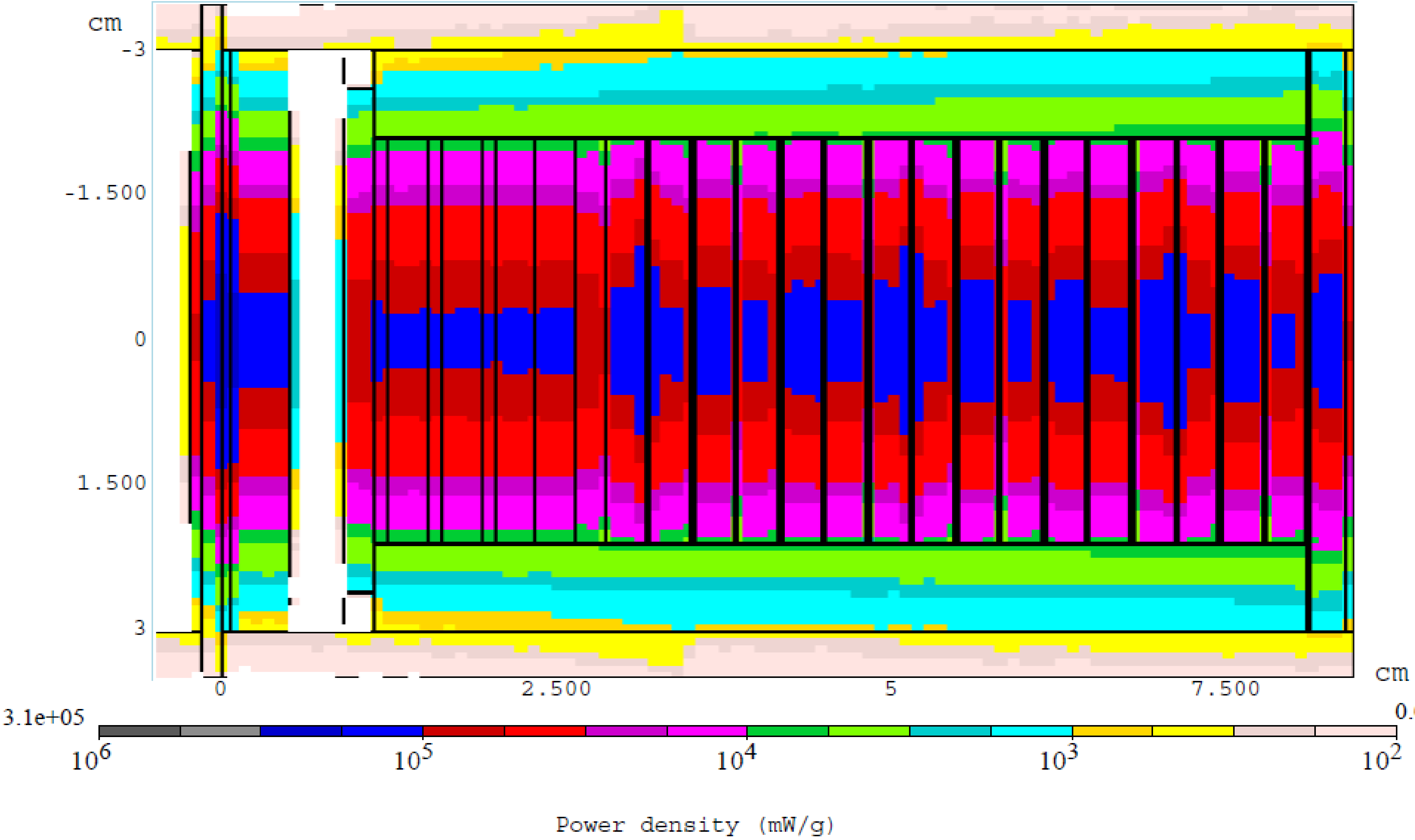


Peak: 2.5e12 $cm^{-3}\ s^{-1}$

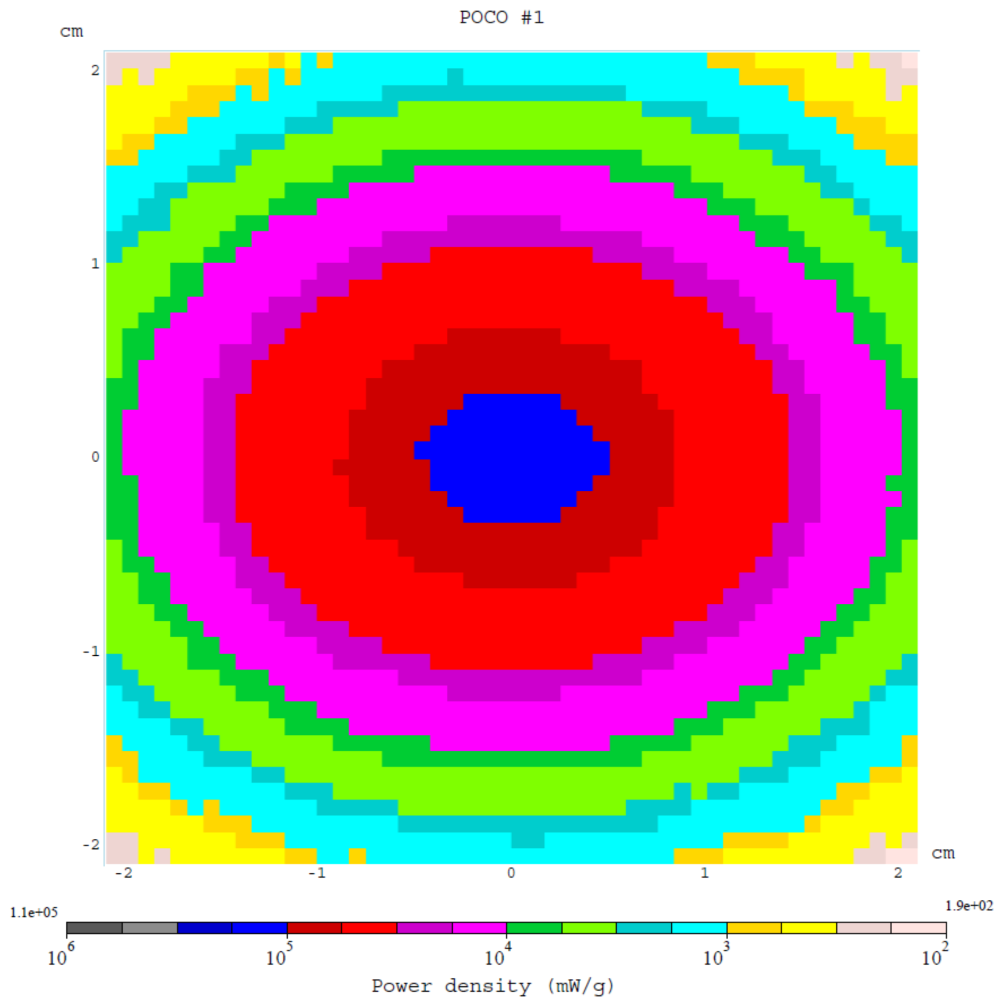
Helium Gas Production

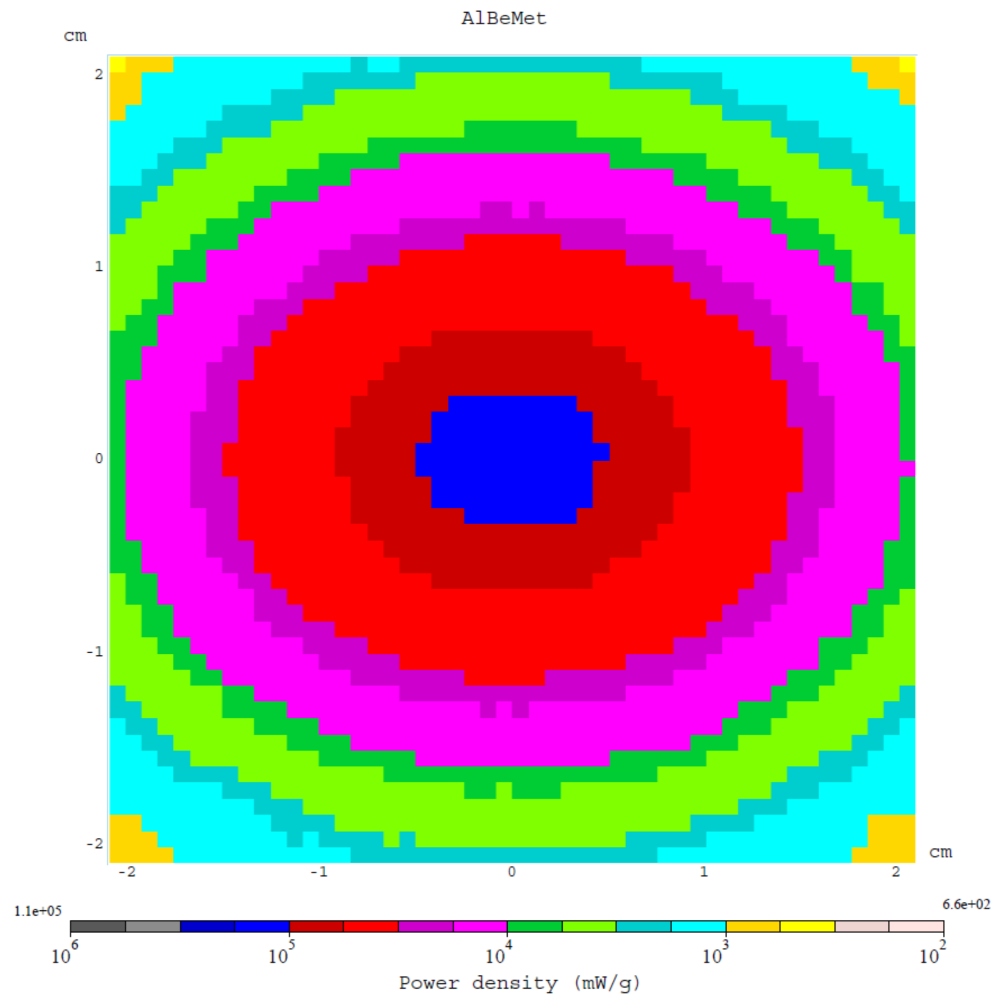


Power Density



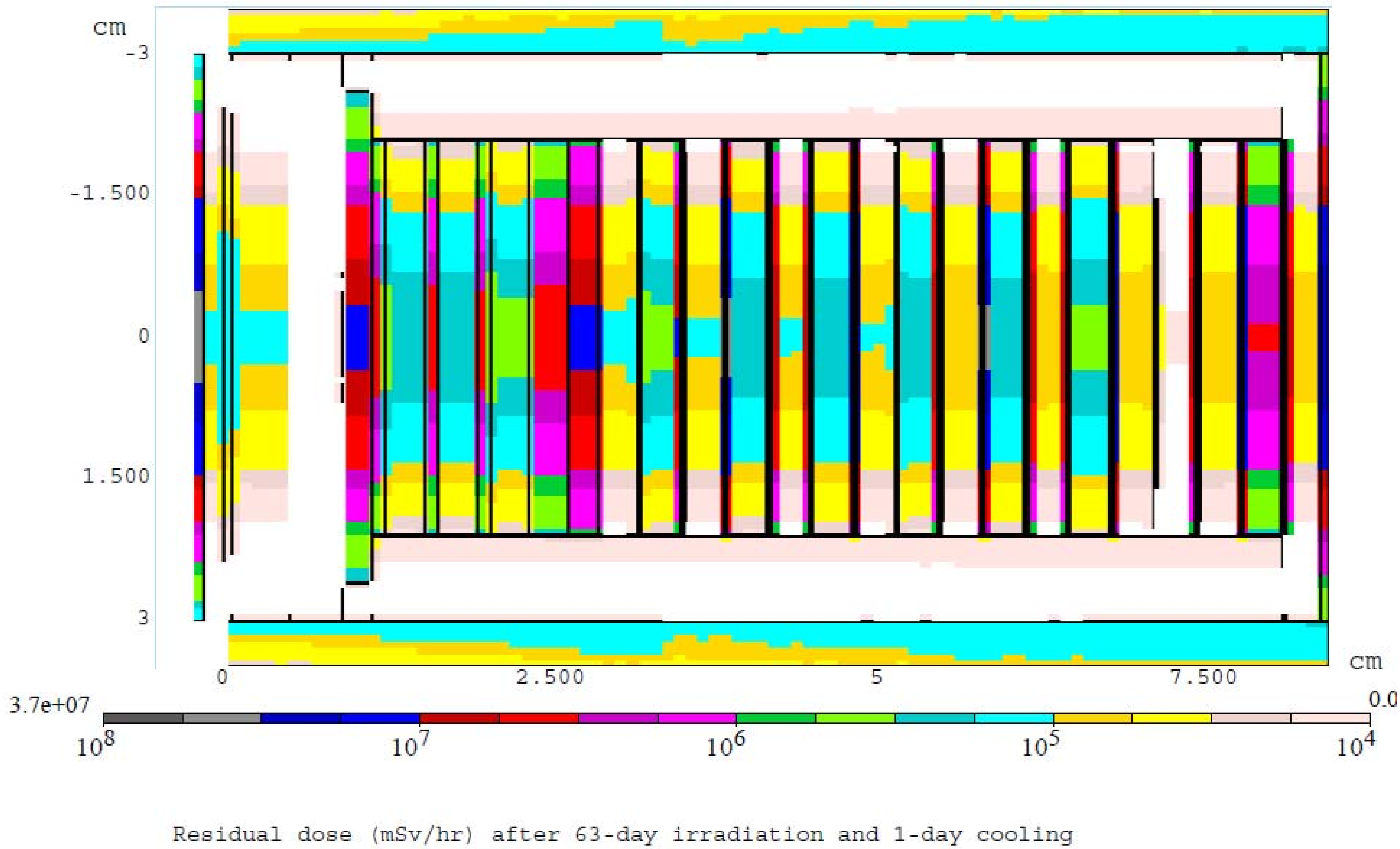
Power Density in 1st (POCO) and 11th (AlBeMet) Samples





Peak: Grows from 113 to 123 W/g when one moves from 1st to 8th graphite sample, 118 W/g in hBN, and 112 W/g in Be & AlBeMet

Residual Dose on Contact after 63/1 days



~50 Sv/hr on BLIP Drive Box

Summary

• Detailed MARS15 calculations performed in the current sample set for the latest BLIP beam parameters. Linac beam energy found for this set is 188 MeV. Calculated distributions are particle fluxes, power density, DPA, hydrogen and helium gas production and residual dose rate.

• All peak values in central samples are a factor of 3 lower compared to the previous numbers because of corresponding increase of the beam spot size.

• Peak DPA in central samples for the 9-week irradiation are 0.11-0.13 in graphite and hBN, 0.06 in Be and 0.3 in AlBeMet. They are 0.01-0.03 DPA in the outer samples, i.e. substantially lower than “desirable” 0.2 DPA value.

• Ways to increase these rates are to decrease the beam spot size to what was originally planned, increase irradiation time and/or increase intensity (?).