Supplementary material - Figures

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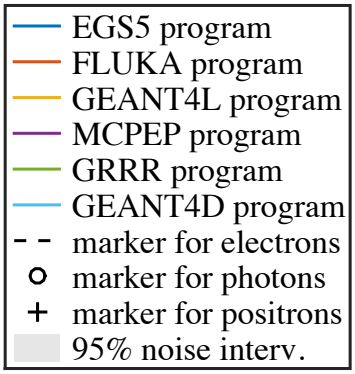
June 8, 2016

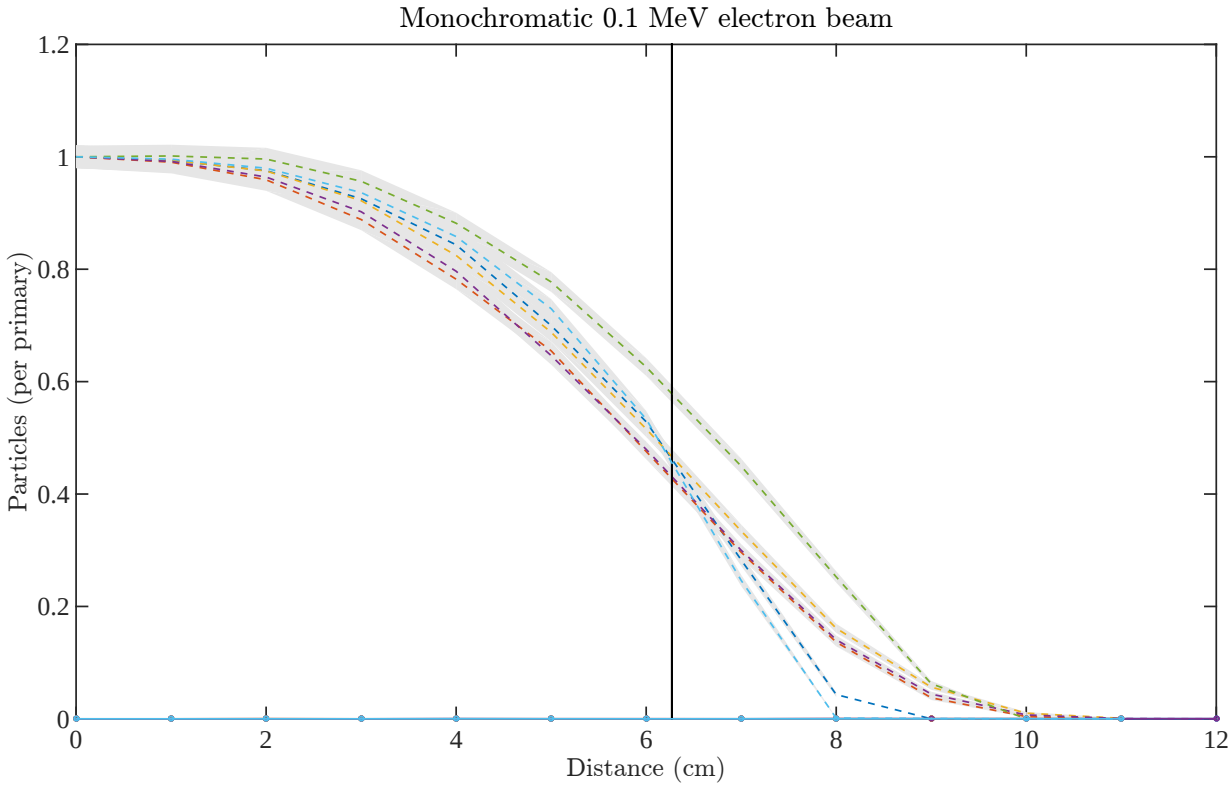
Abstract

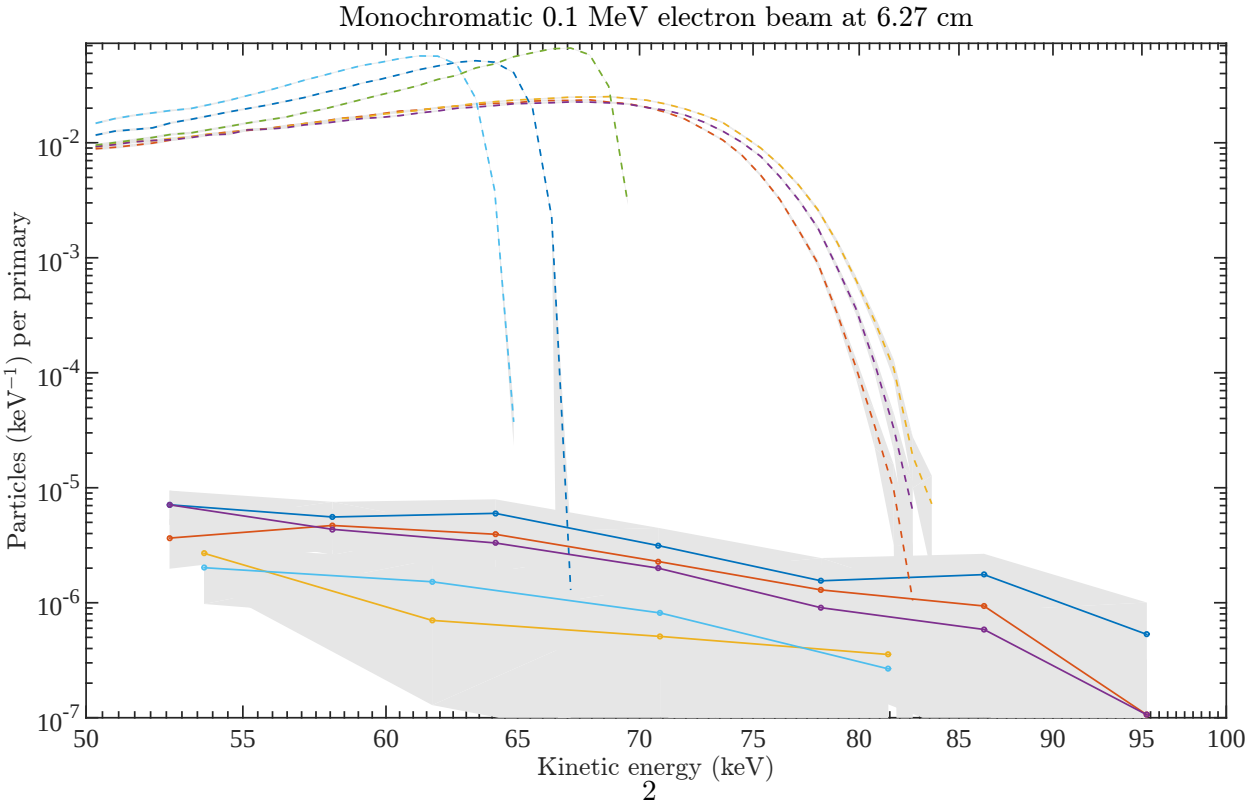
We study electron, positron and photon avalanches through air, consisting of 78.085% nitrogen, 20.95% oxygen and 0.965% argon, with kinetic energies starting with 0.1 MeV, 0.4 MeV, 1.0 MeV, 10 MeV and 40 MeV. We use a constant and homogenous density of 1.293×10^{-3} g cm^{-3}. The distances considered up to one CSDA range for electrons and positrons and four times the inverse of the attenuation coefficient (four e-folding lengths) for the photons. For each distance we preform at least 10k initial particles. The spectra are simulated at one half CSDA range for electrons and positrons and two times the inverse of the attenuation coefficient (two e-folding lengths). The spectra are simulated with 1 million initial particles.

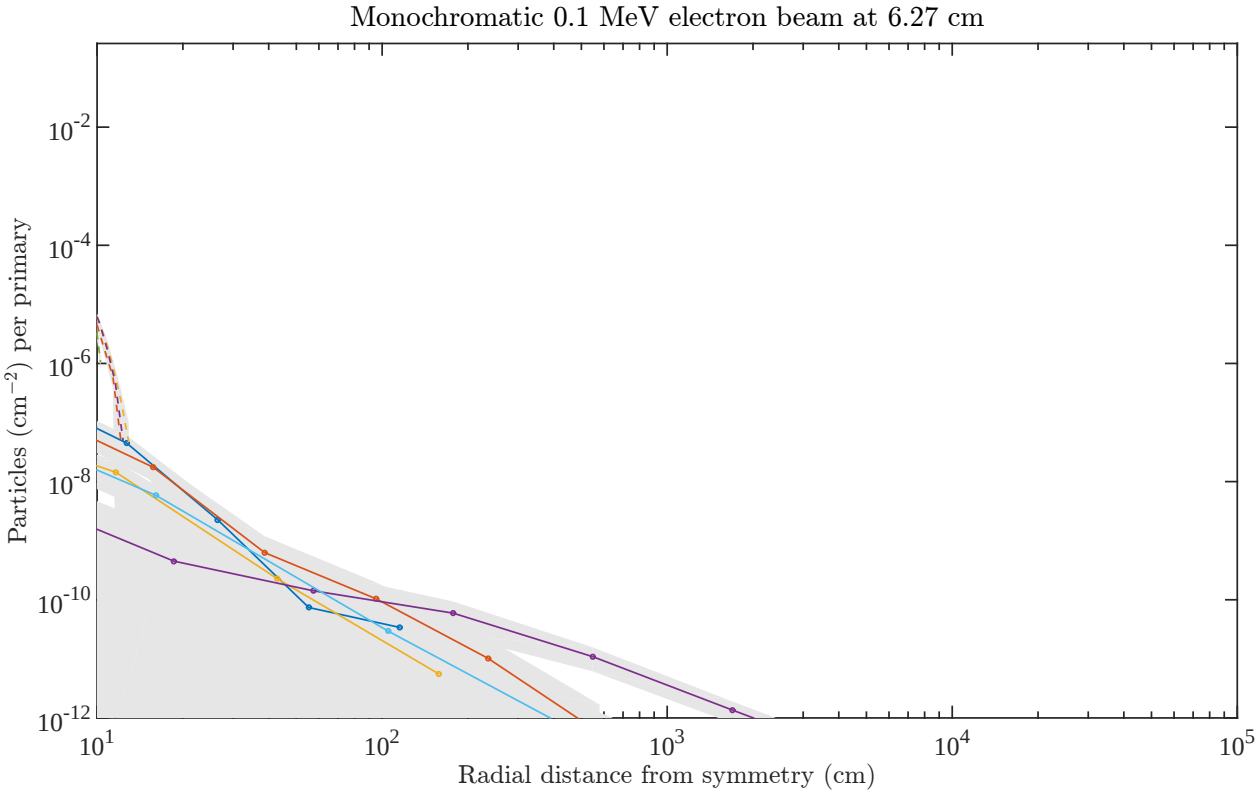


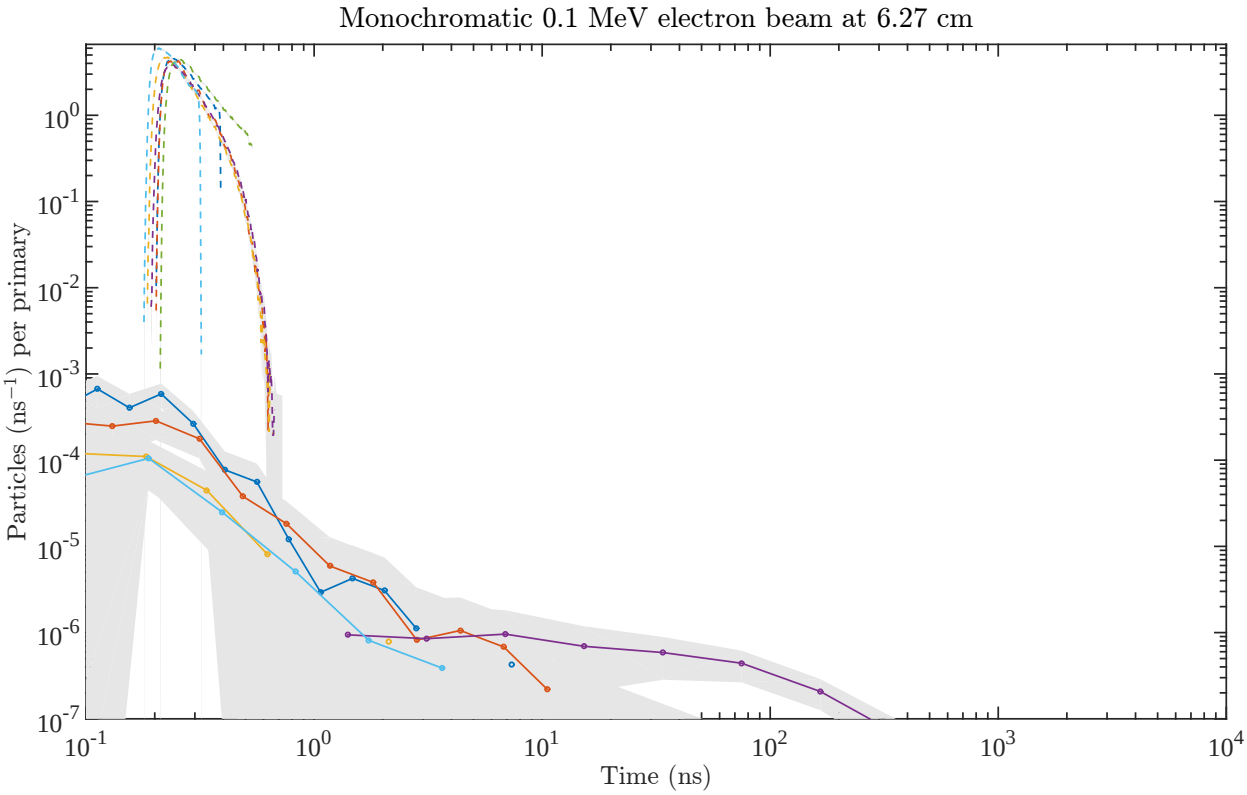
1 Monochromatic electron beams

1.1 Initial 0.1 MeV kinetic energy, detector distance at 6.27 cm

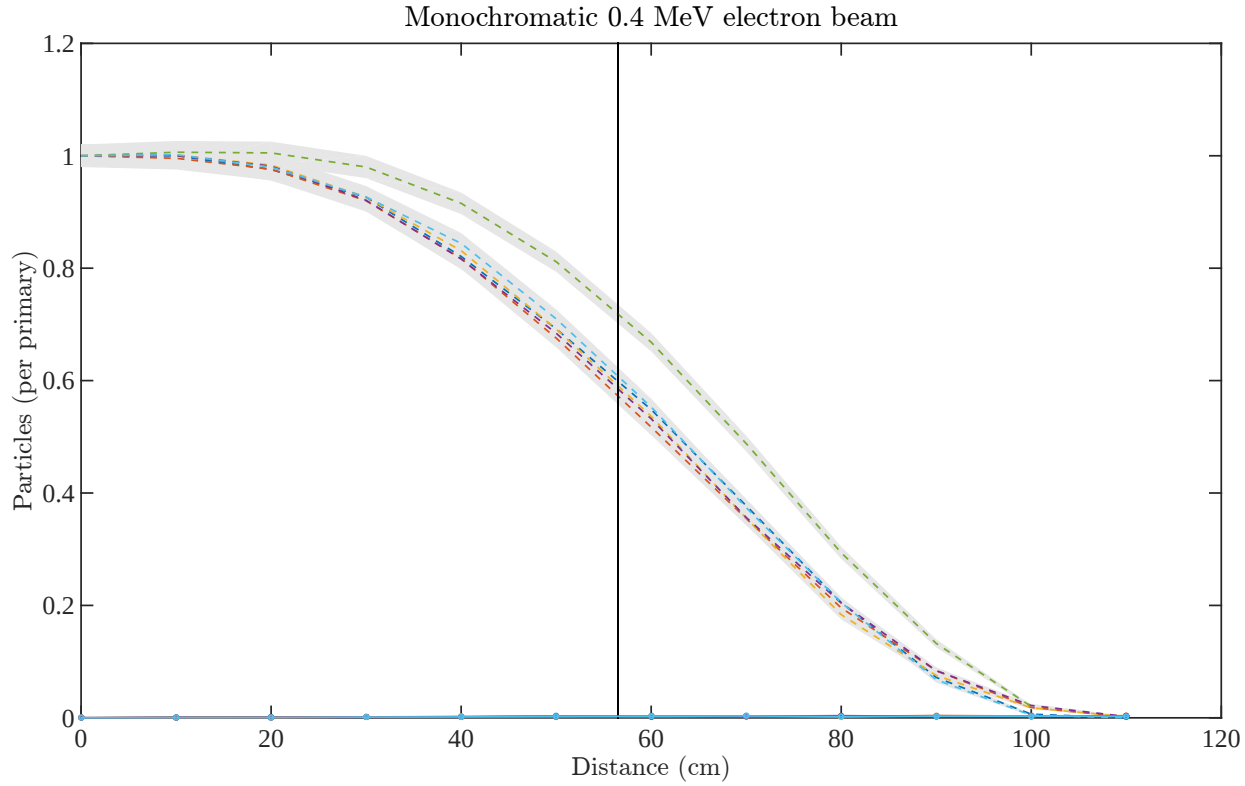


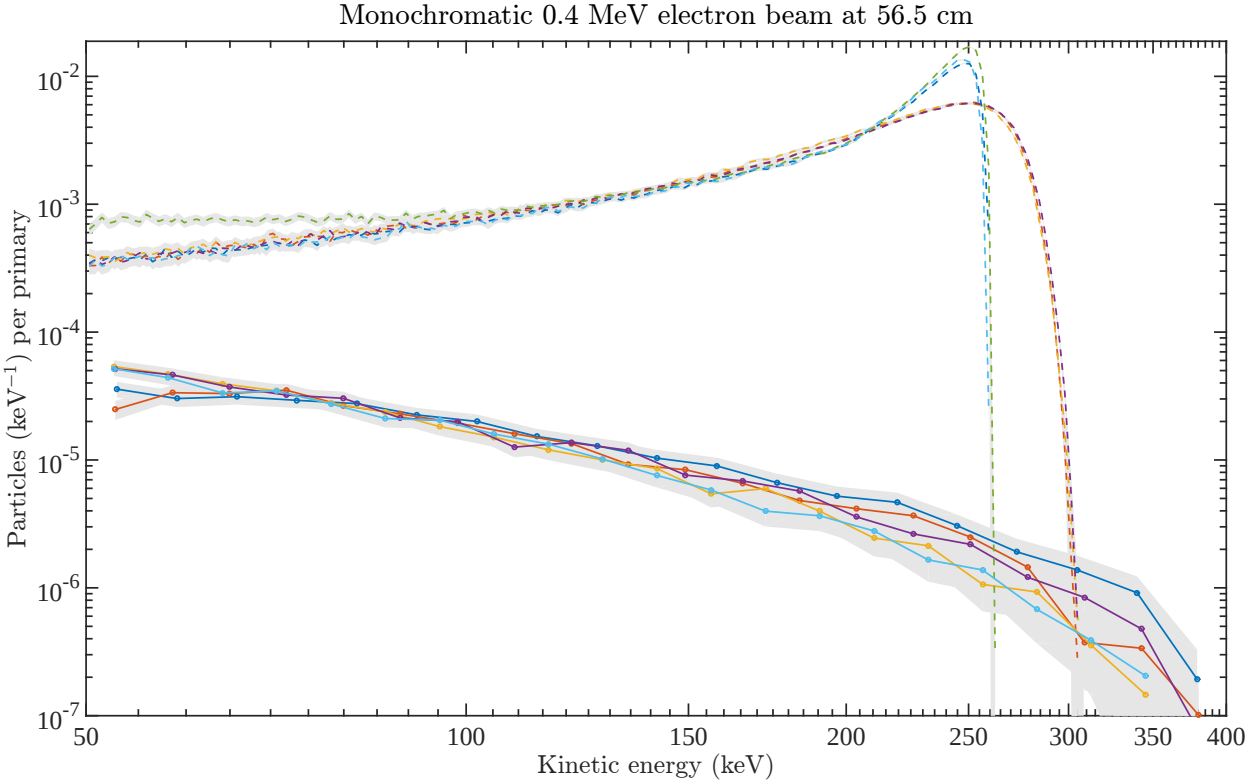


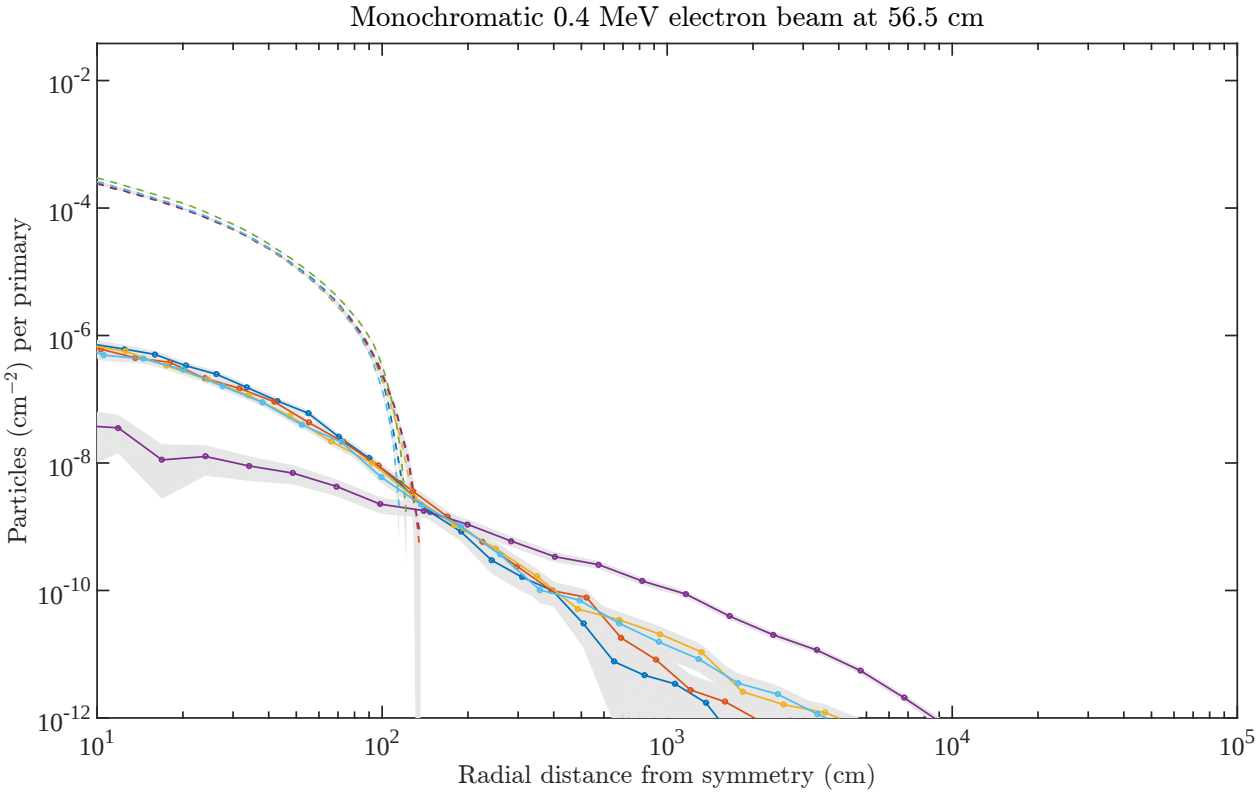

Monochromatic 0.1 MeV electron beam at 6.27 cm
Particles (cm^{-2}) per primary
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
Radial distance from symmetry (cm)

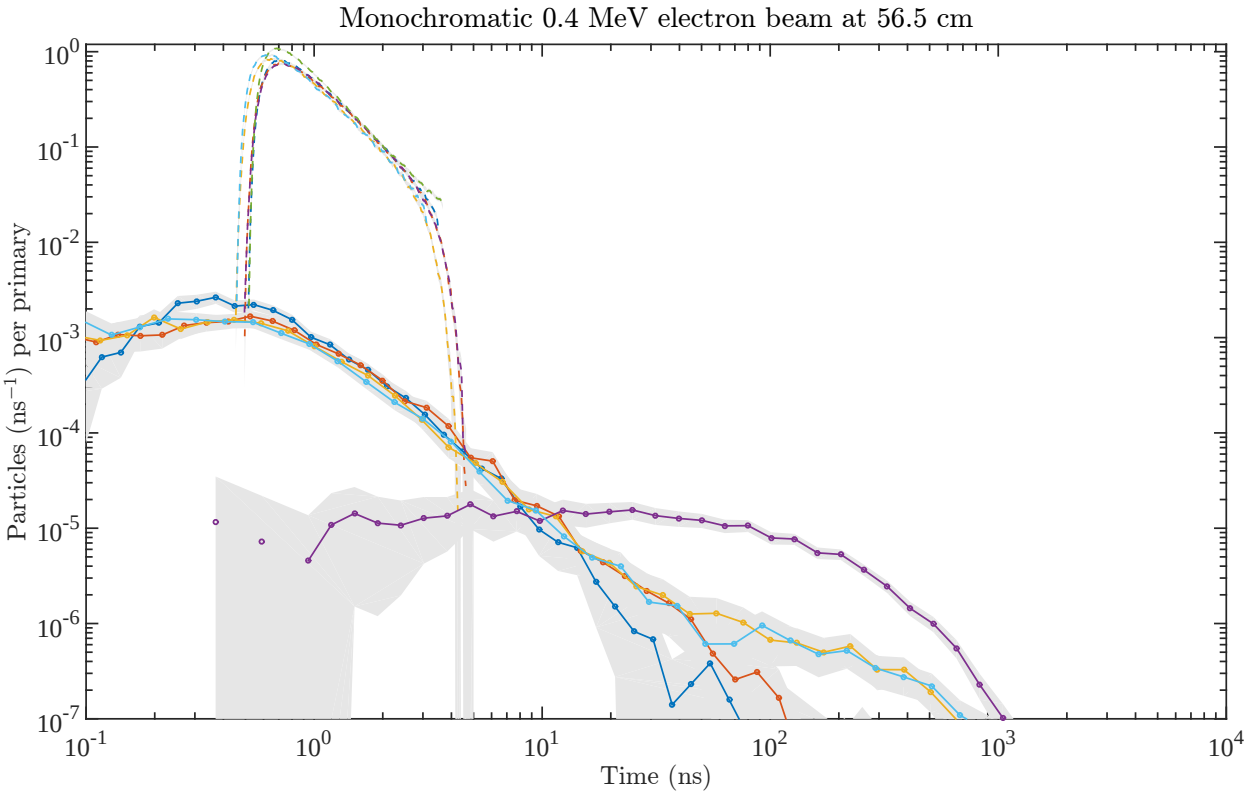

Monochromatic 0.1 MeV electron beam at 6.27 cm
Particles (ns^{-1}) per primary
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Time (ns)

1.2 Initial 0.4 MeV kinetic energy, detector distance at 56.5 cm

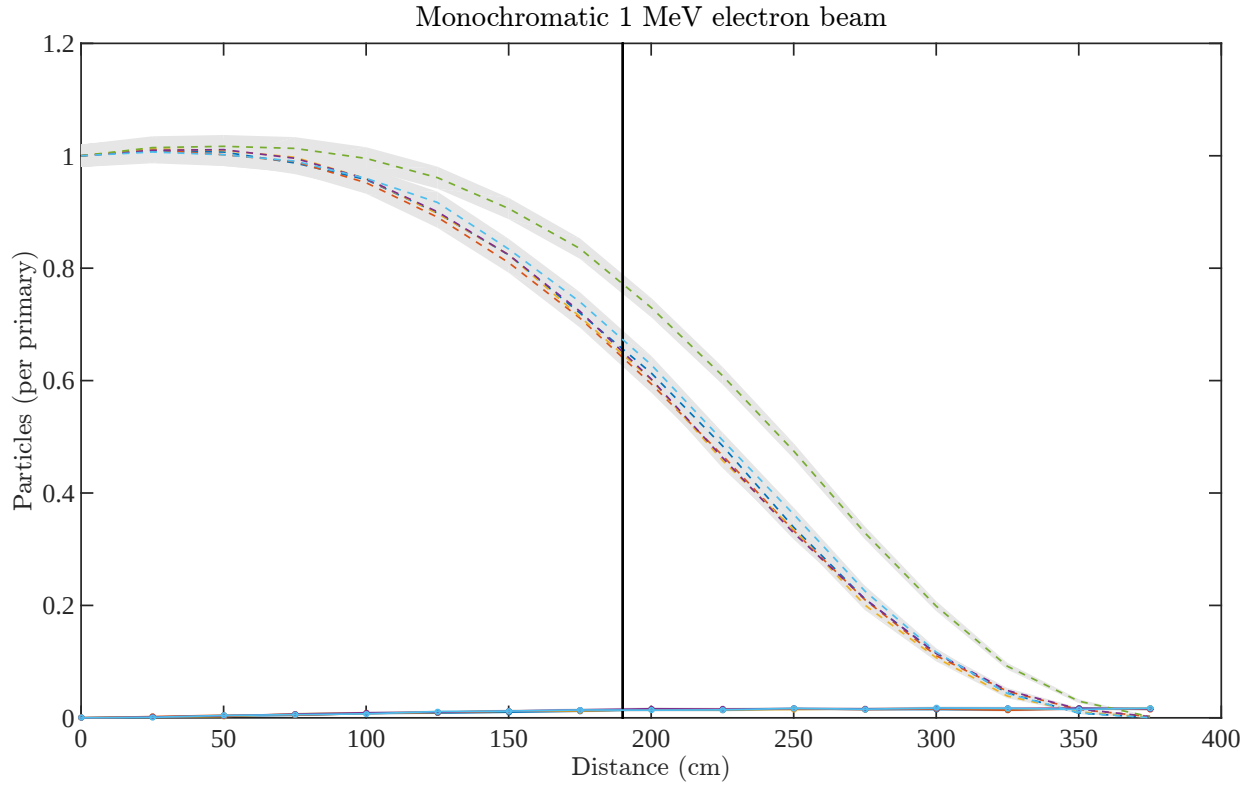


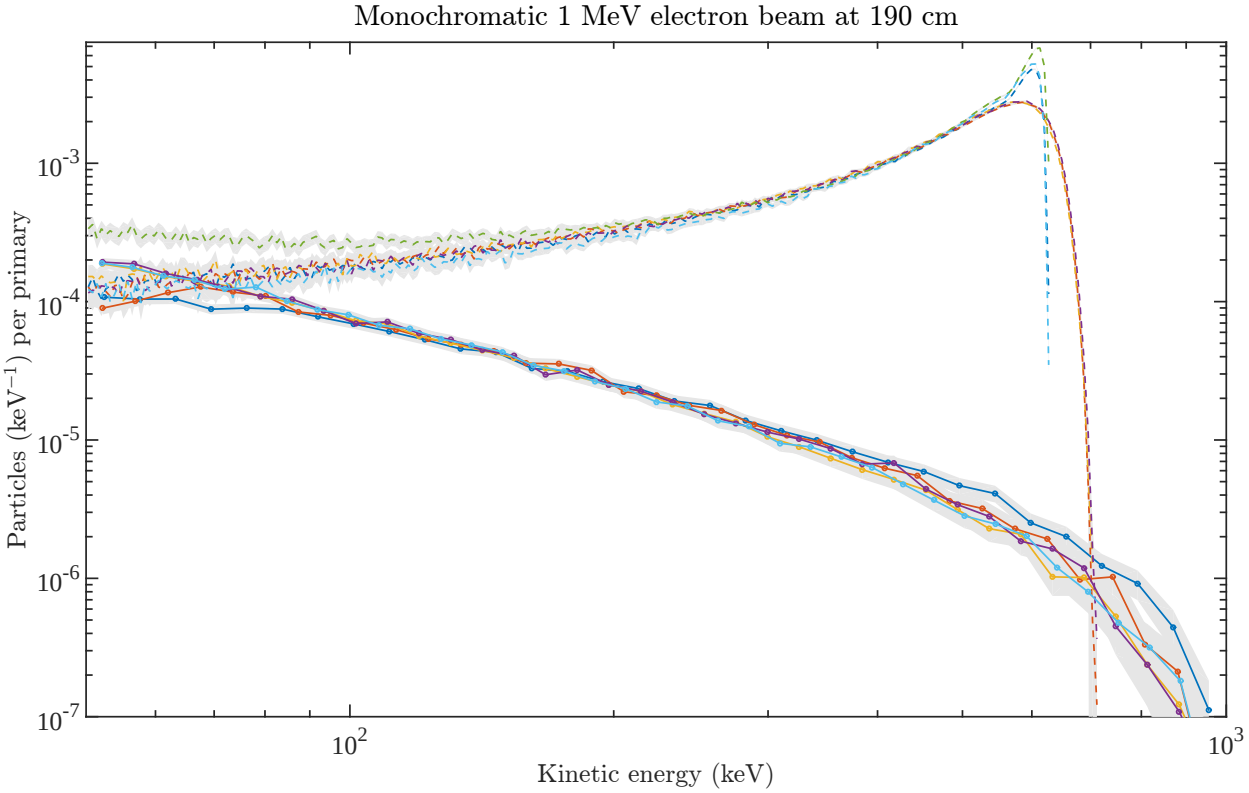


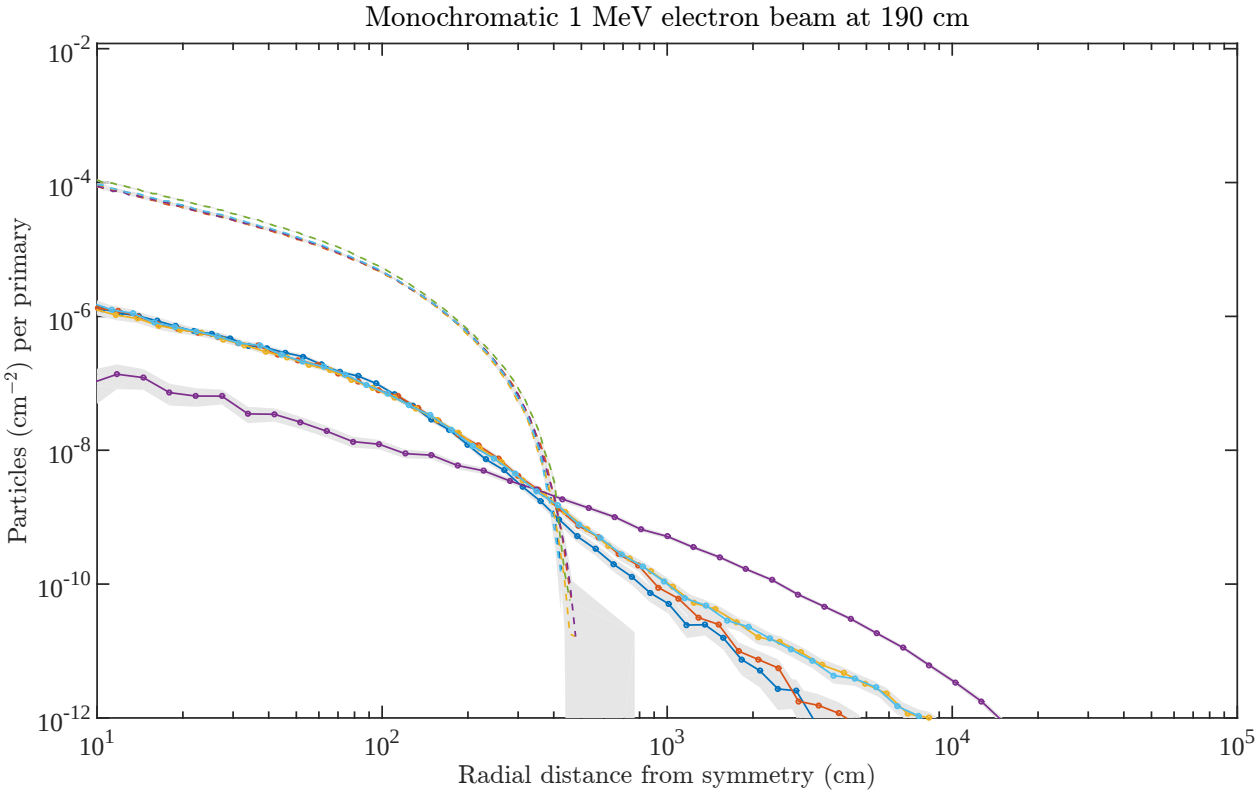

Monochromatic 0.4 MeV electron beam at 56.5 cm
Particles (cm^{-2}) per primary
Radial distance from symmetry (cm)

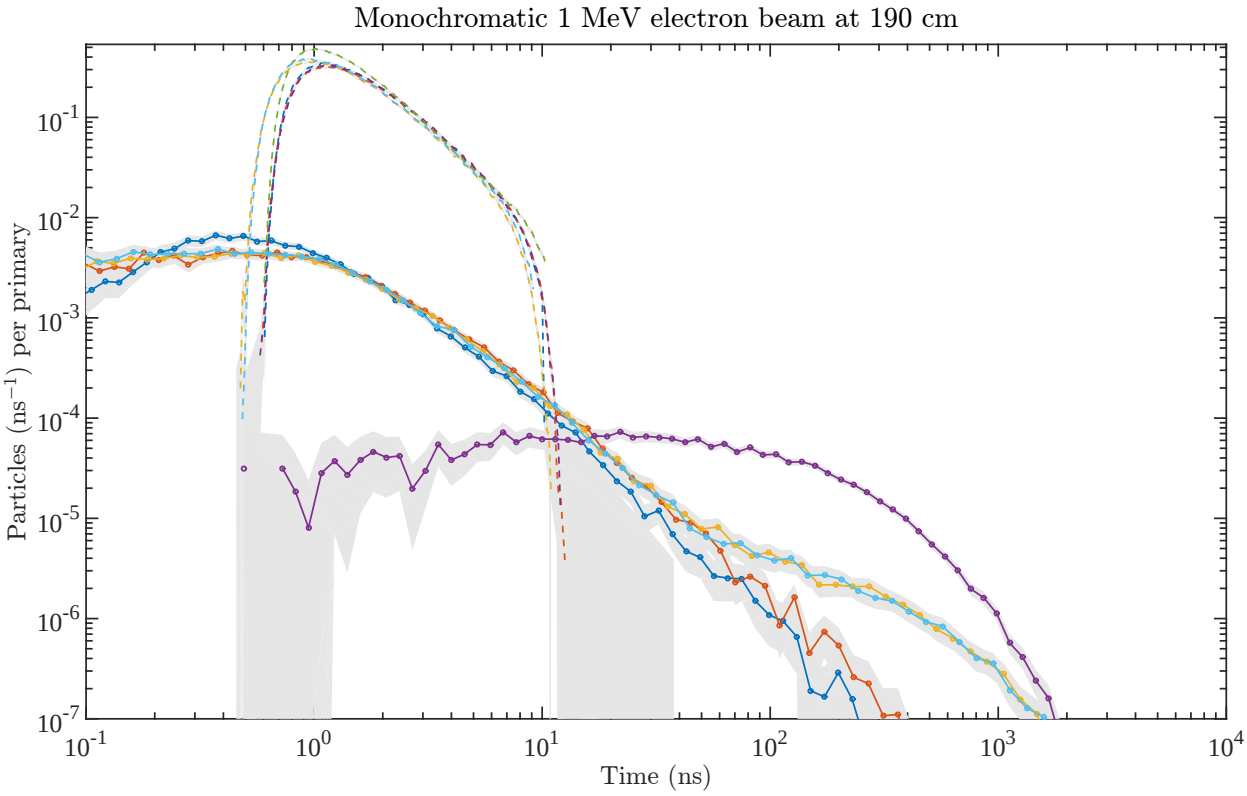

Monochromatic 0.4 MeV electron beam at 56.5 cm
Particles (ns^{-1}) per primary
Time (ns)

1.3 Initial 1.0 MeV kinetic energy, detector distance at 190 cm

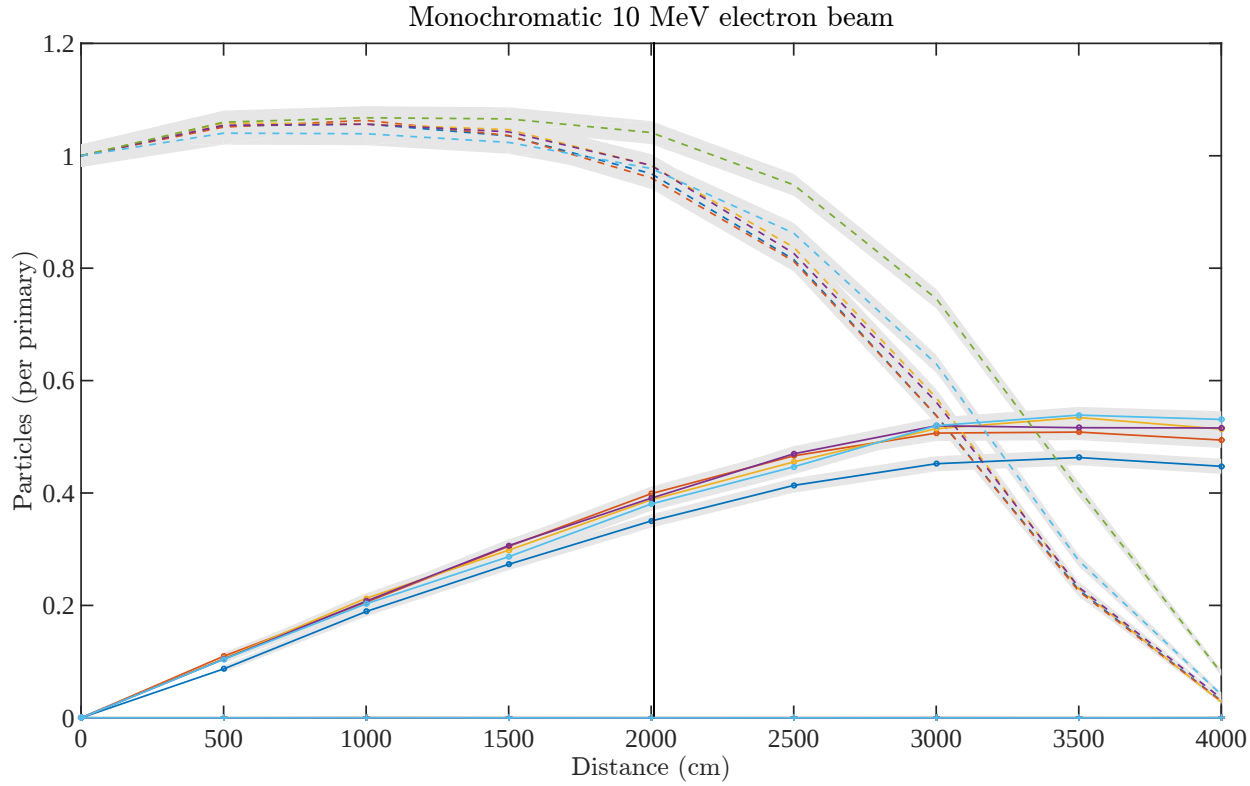


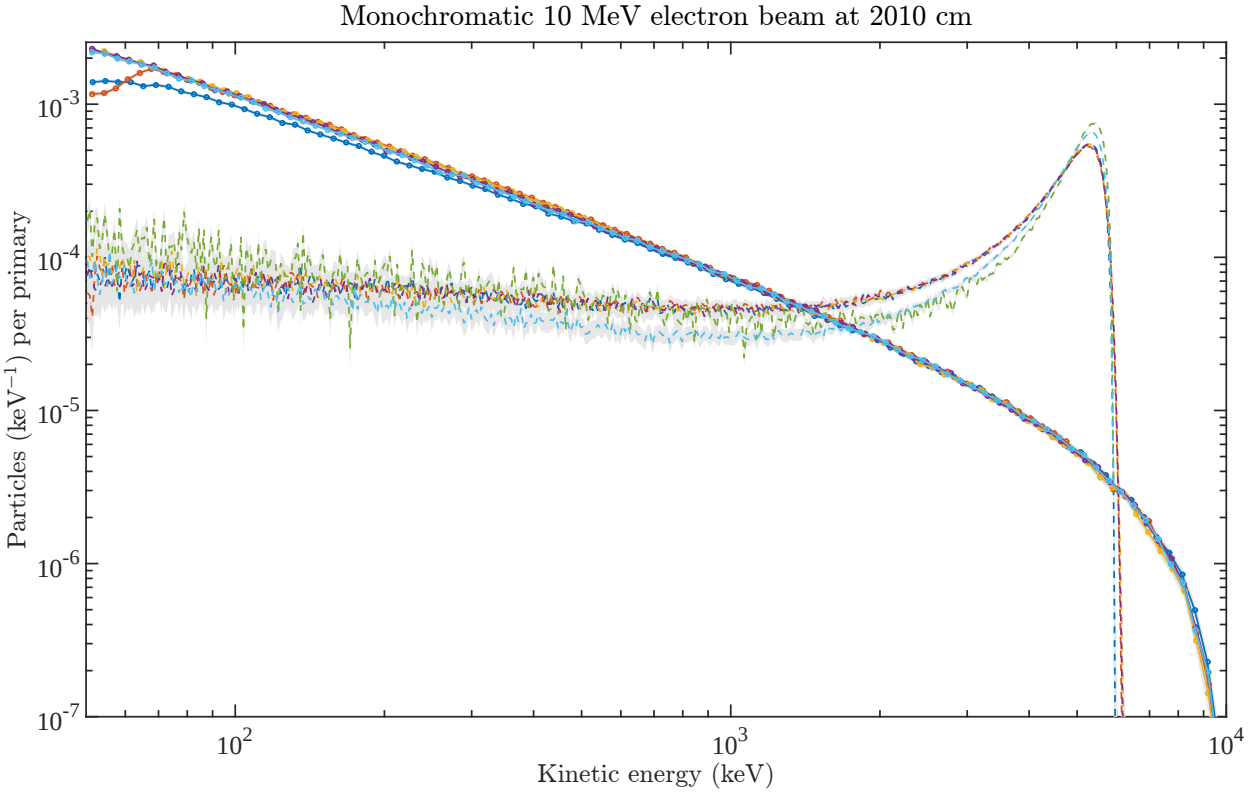


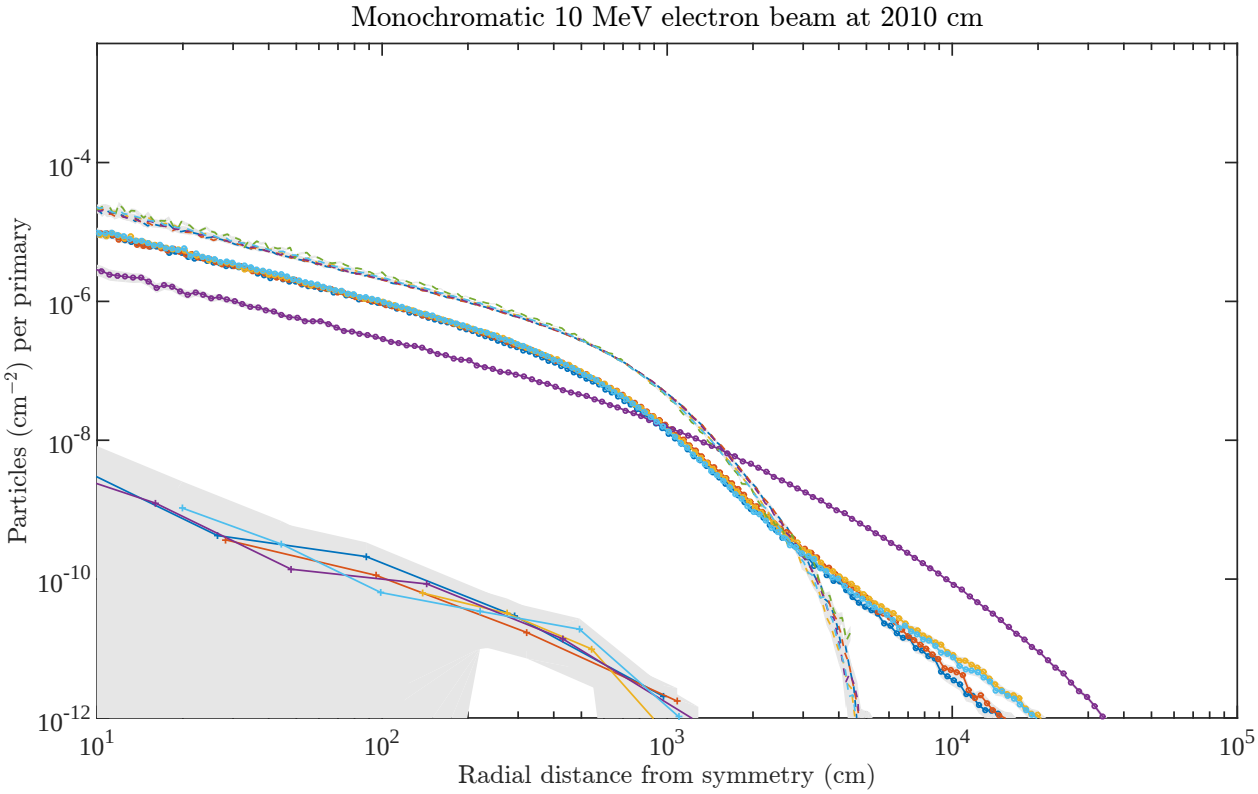

Monochromatic 1 MeV electron beam at 190 cm
Particles (cm^{-2}) per primary
Radial distance from symmetry (cm)

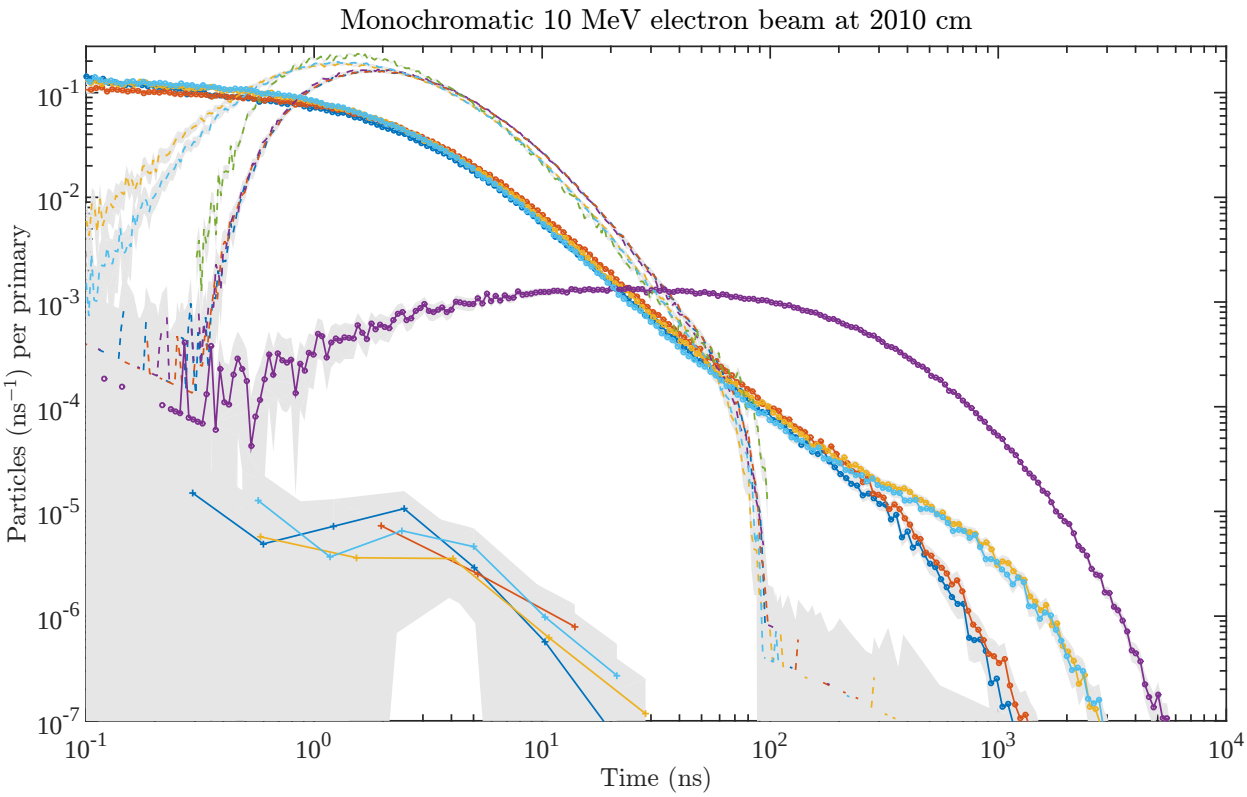

Monochromatic 1 MeV electron beam at 190 cm
Particles (ns^{-1}) per primary
Time (ns)

1.4 Initial 10 MeV kinetic energy, detector distance at 2010 cm

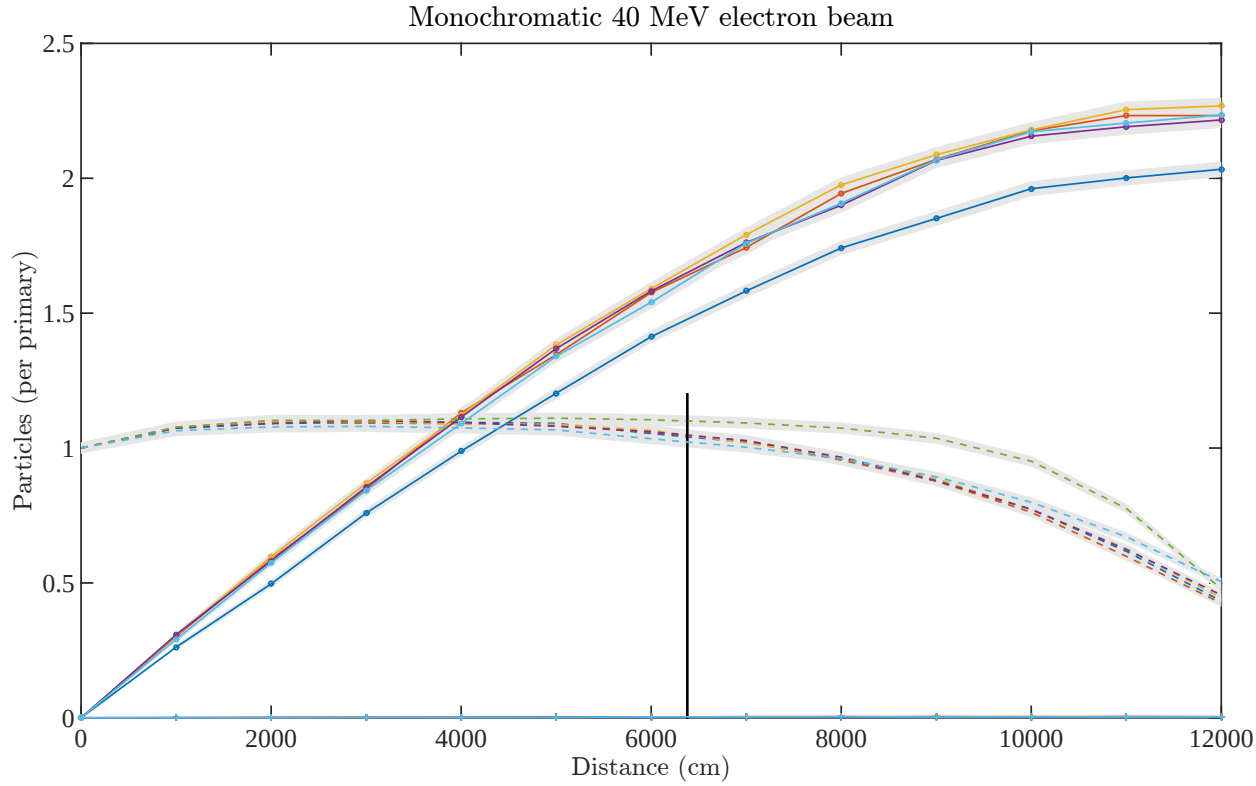


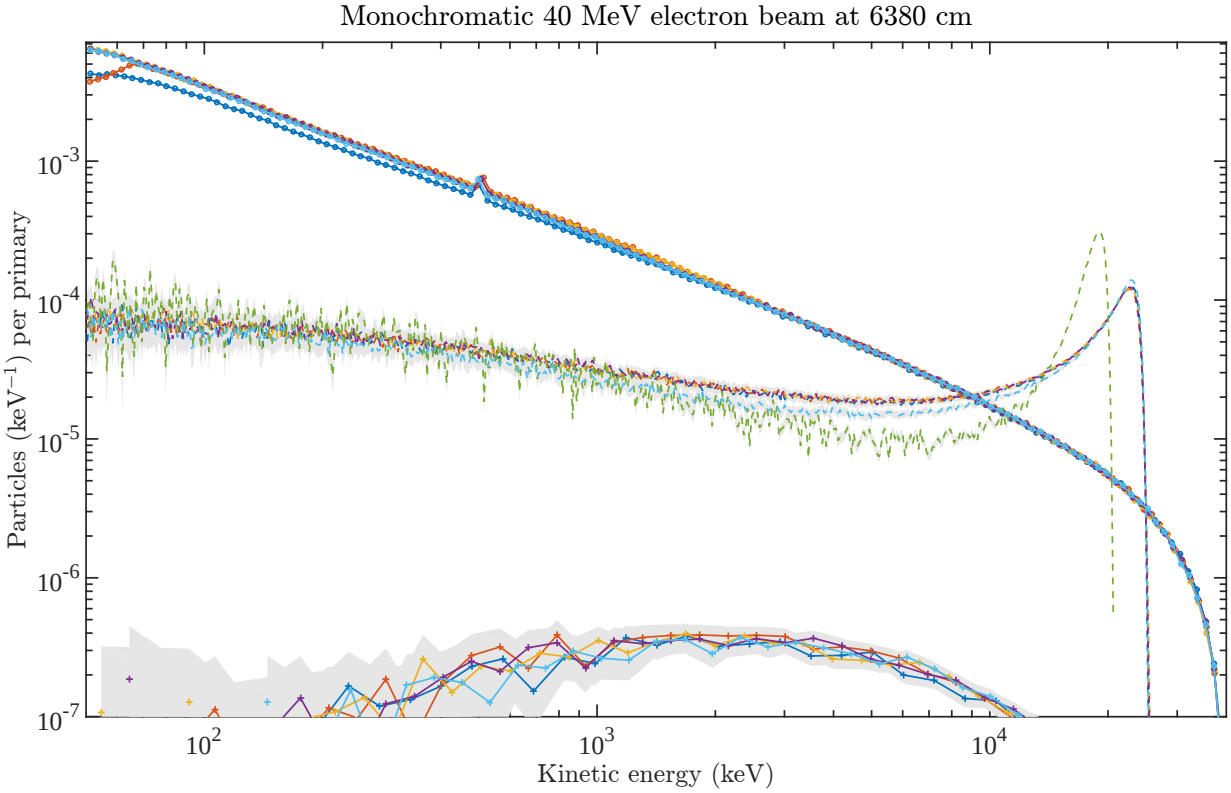


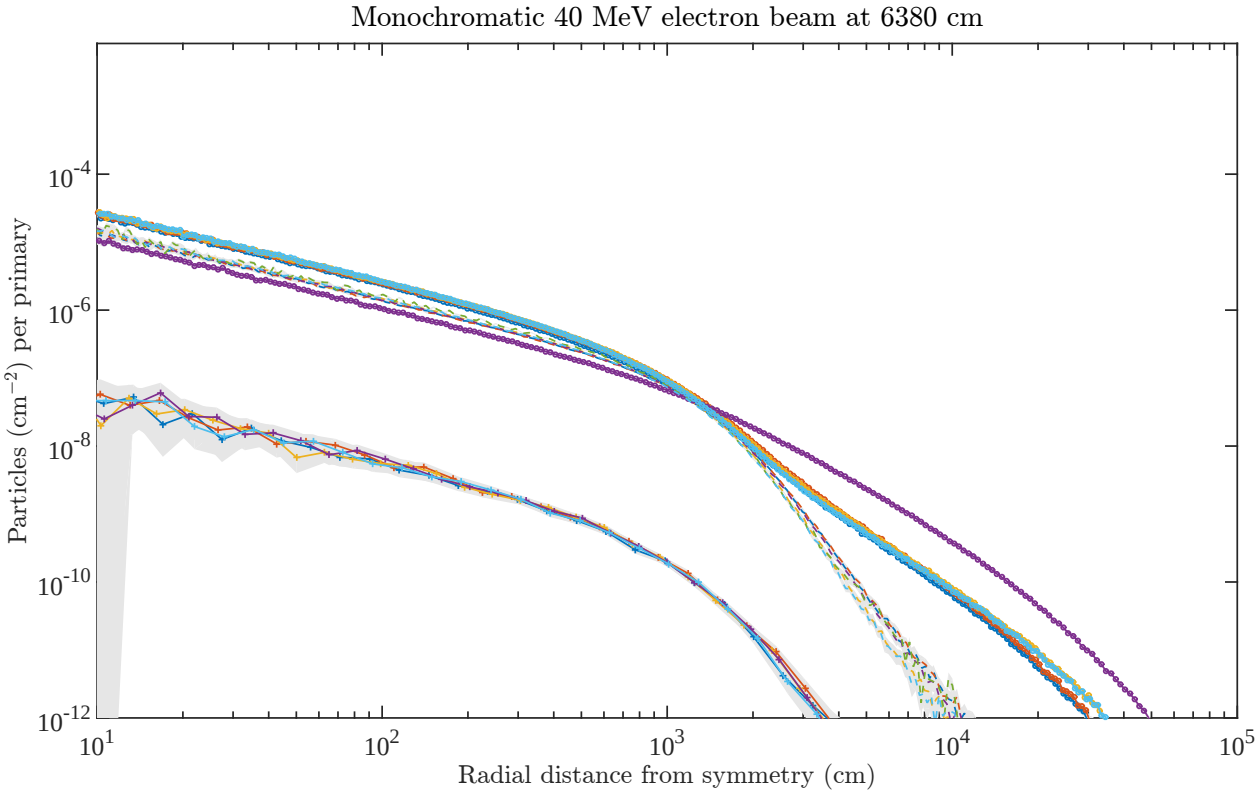

Monochromatic 10 MeV electron beam at 2010 cm
Particles (cm^{-2}) per primary
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
Radial distance from symmetry (cm)

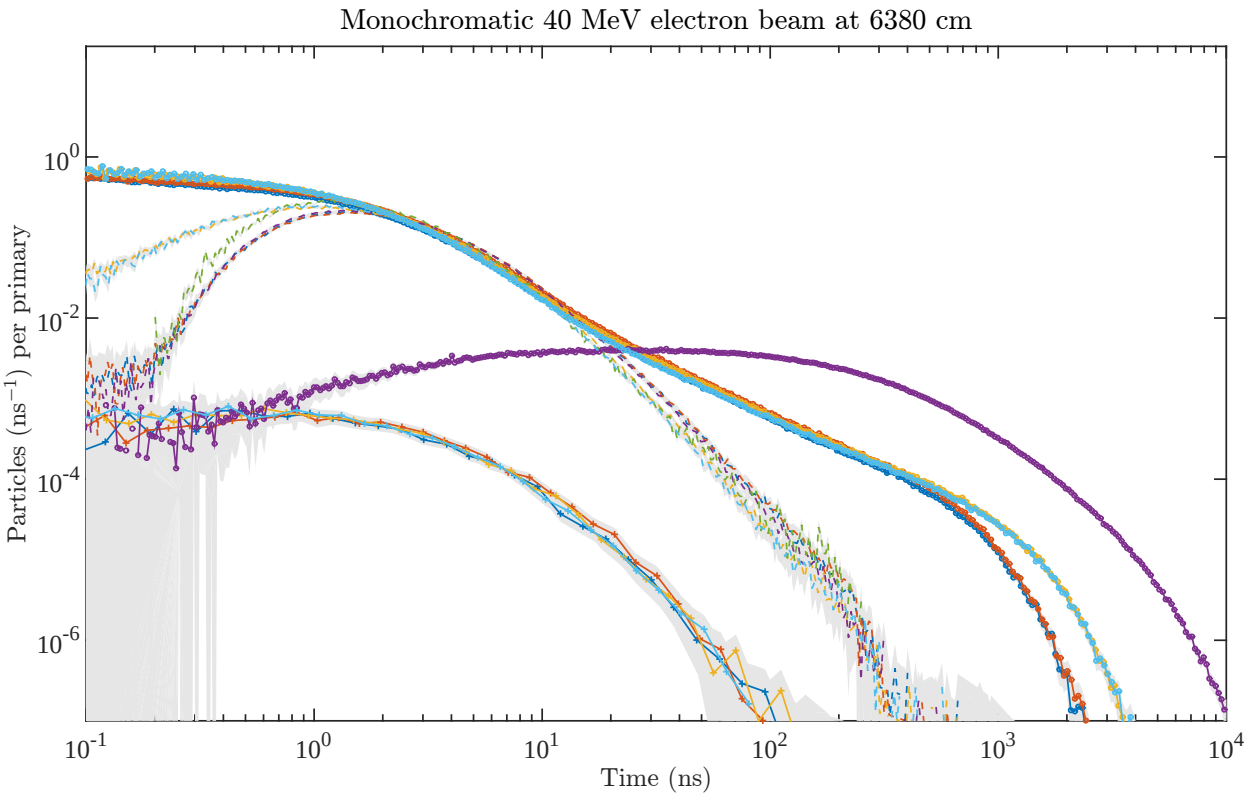

Monochromatic 10 MeV electron beam at 2010 cm
Particles (ns^{-1}) per primary
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Time (ns)

1.5 Initial 40 MeV kinetic energy, detector distance at 6380 cm



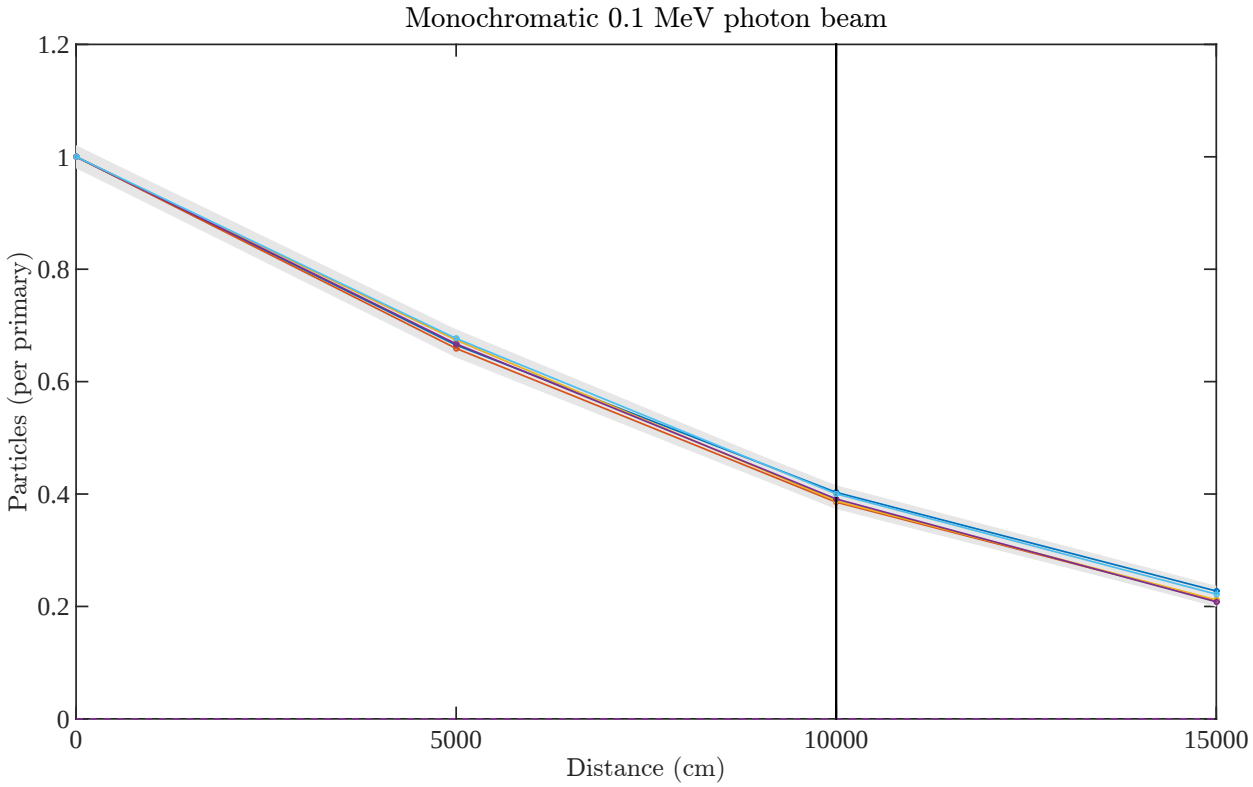


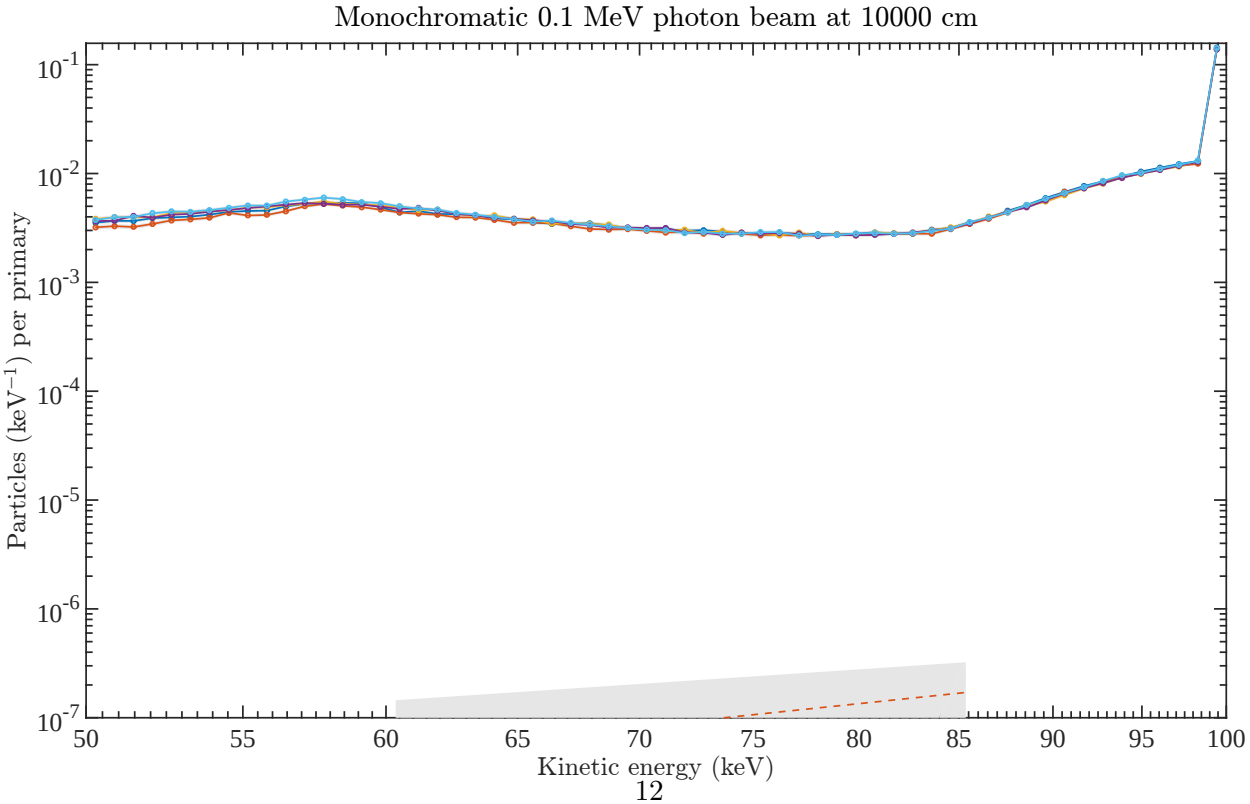

Monochromatic 40 MeV electron beam at 6380 cm
Particles (cm^{-2}) per primary
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
Radial distance from symmetry (cm)

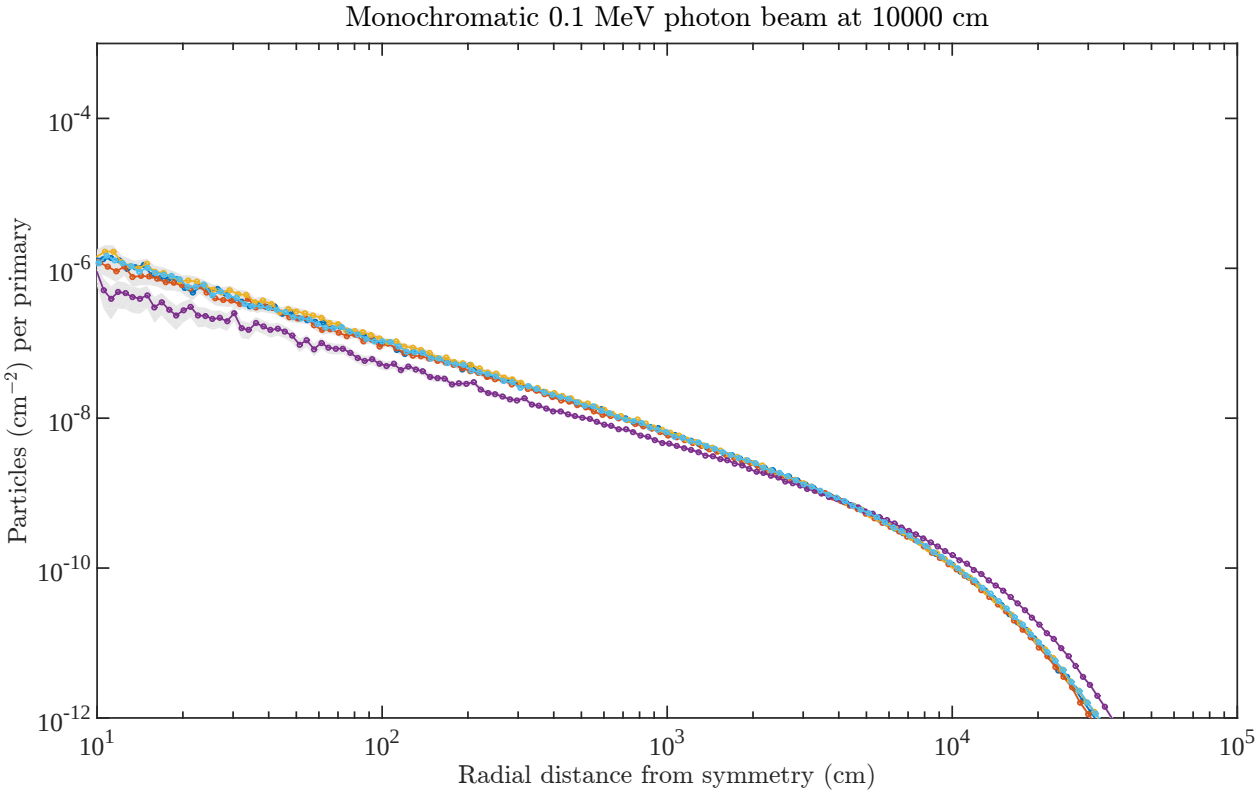

Monochromatic 40 MeV electron beam at 6380 cm
Particles (ns^{-1}) per primary
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Time (ns)

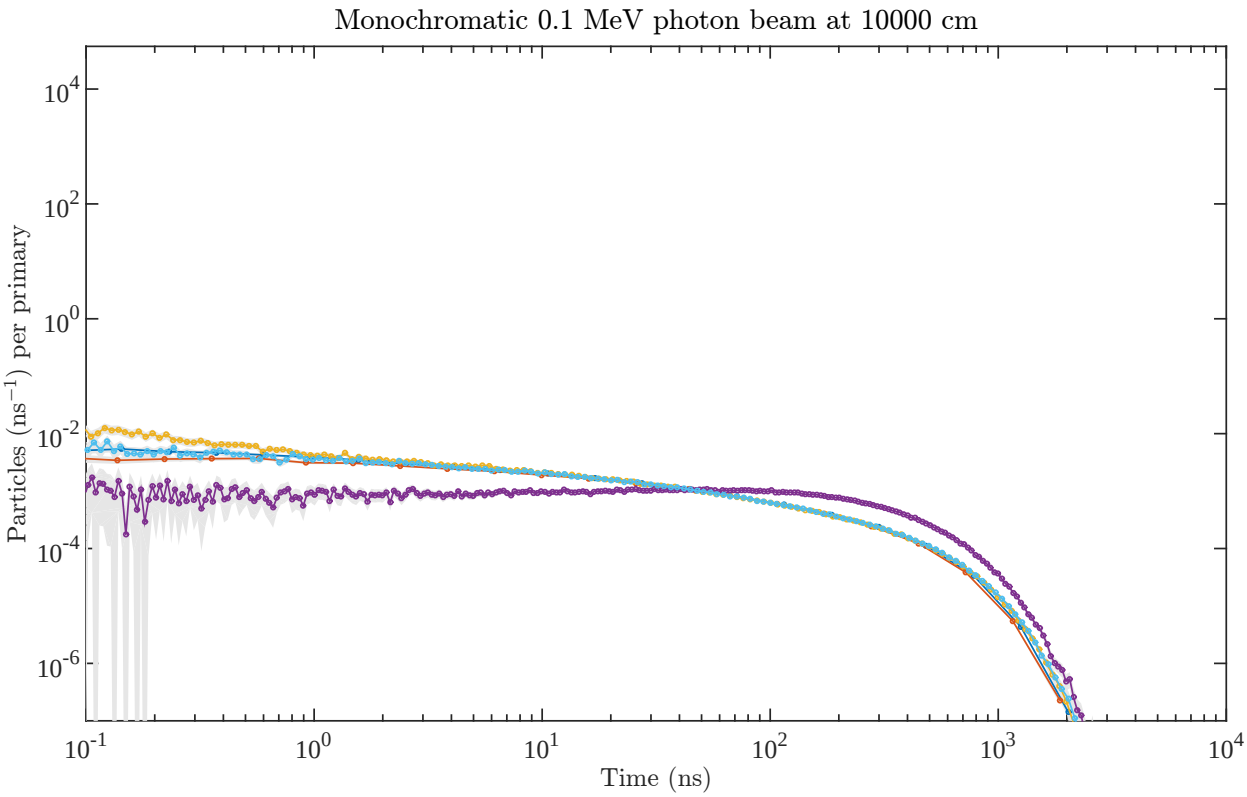
2 Monochromatic photon beams

2.1 Initial 0.1 MeV kinetic energy, detector distance at 10000 cm

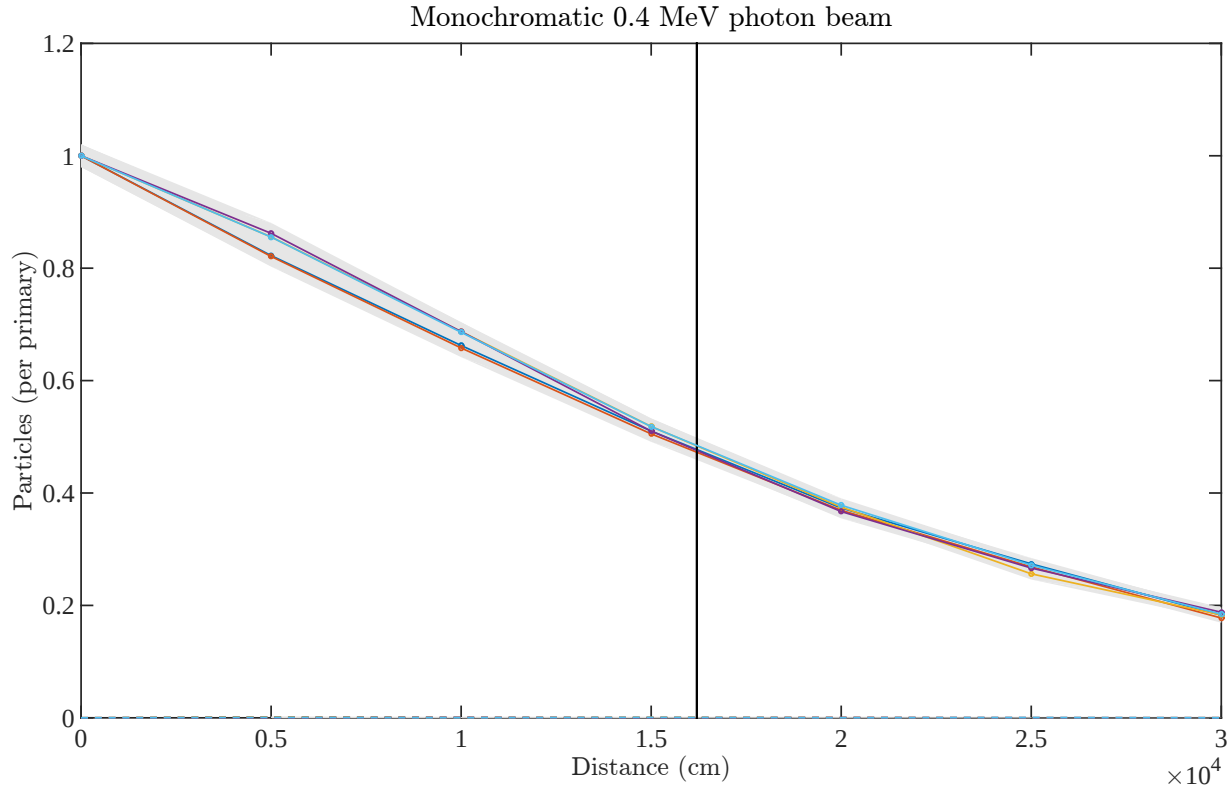


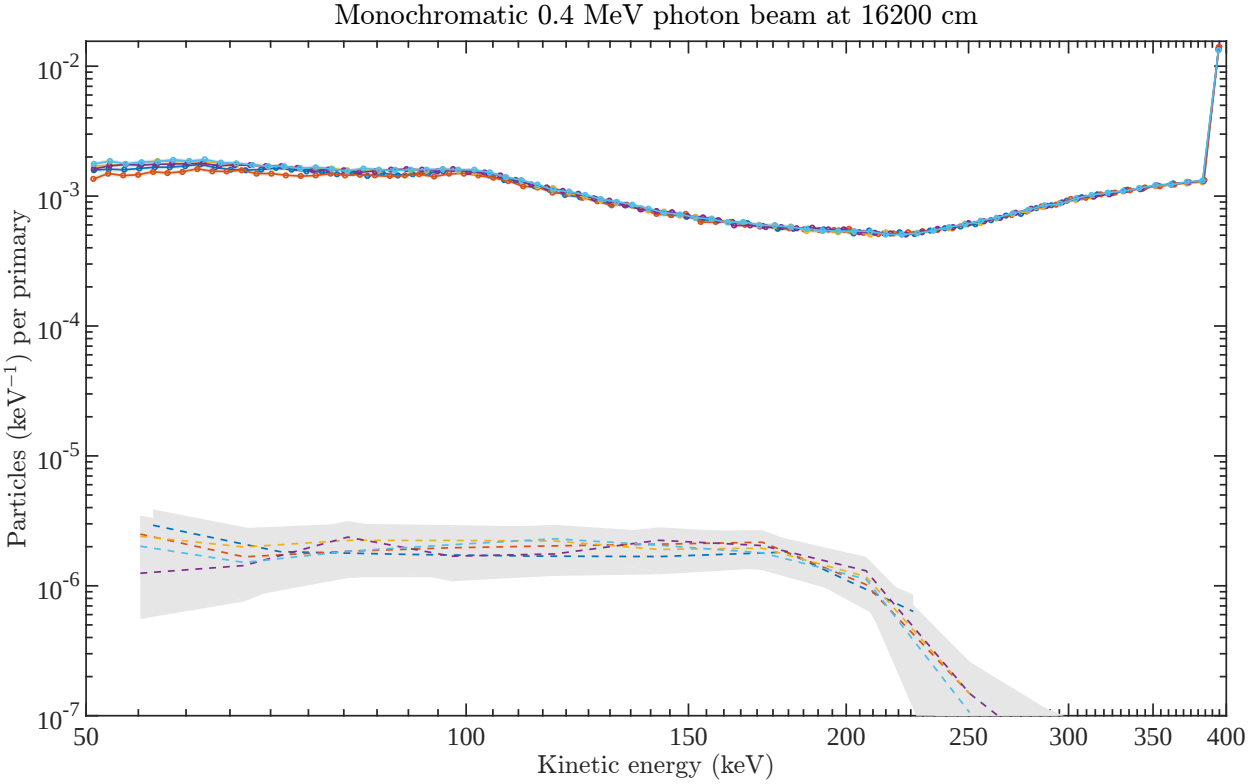


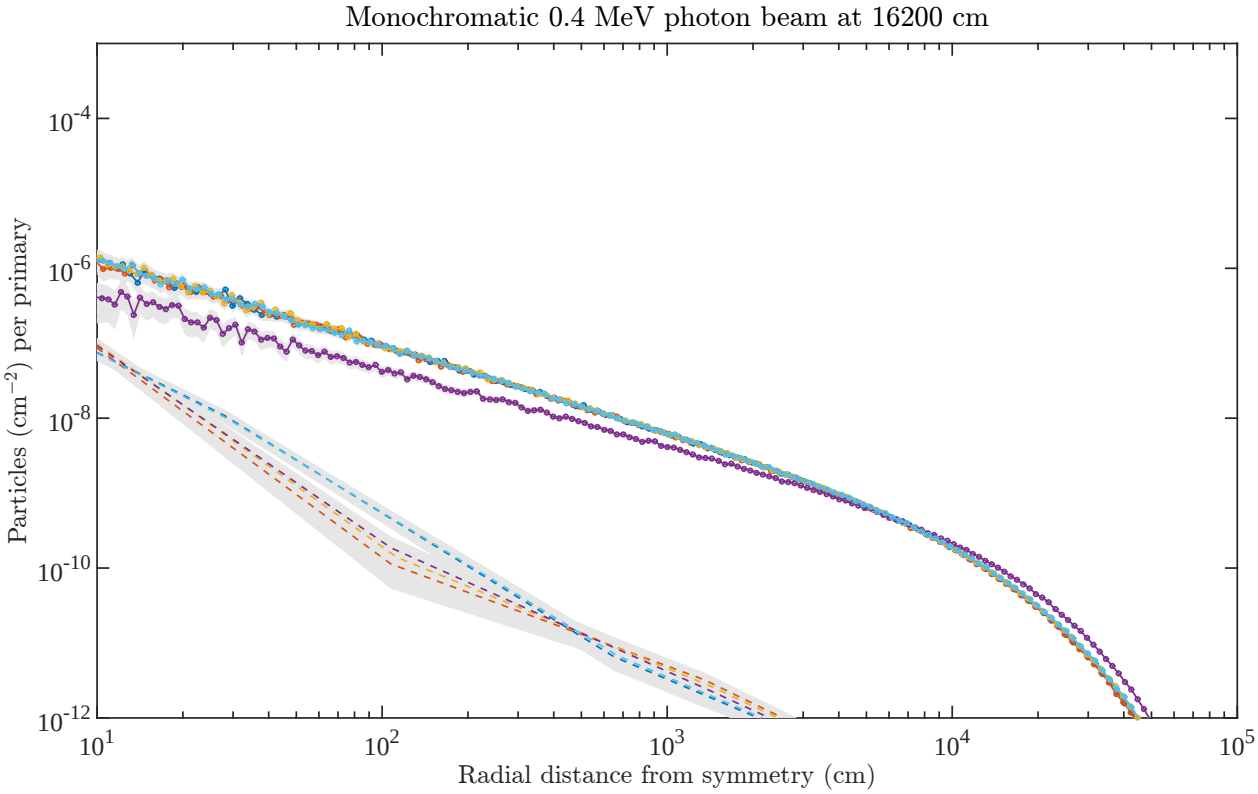

Monochromatic 0.1 MeV photon beam at 10000 cm
Particles (cm^{-2}) per primary
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
Radial distance from symmetry (cm)

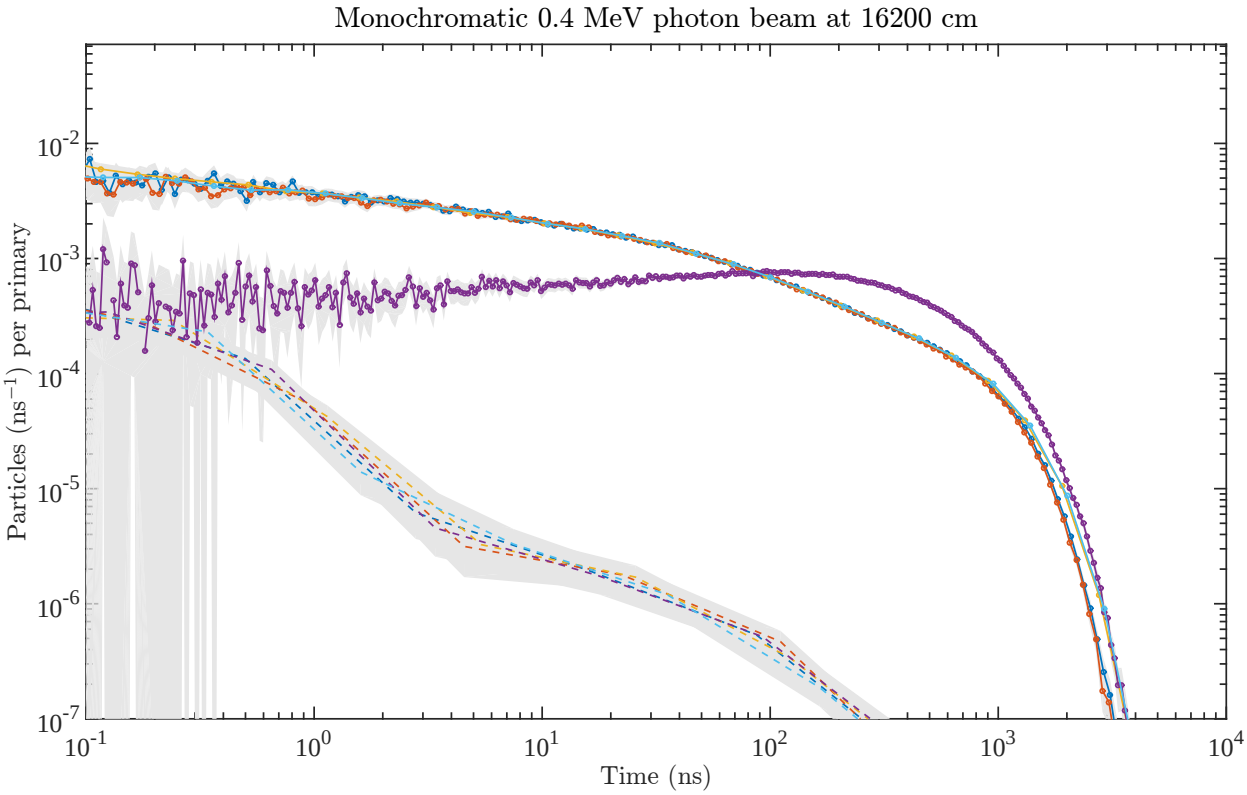

Monochromatic 0.1 MeV photon beam at 10000 cm
Particles (ns^{-1}) per primary
10^{4}
10^{2}
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Time (ns)

2.2 Initial 0.4 MeV kinetic energy, detector distance at 16200 cm

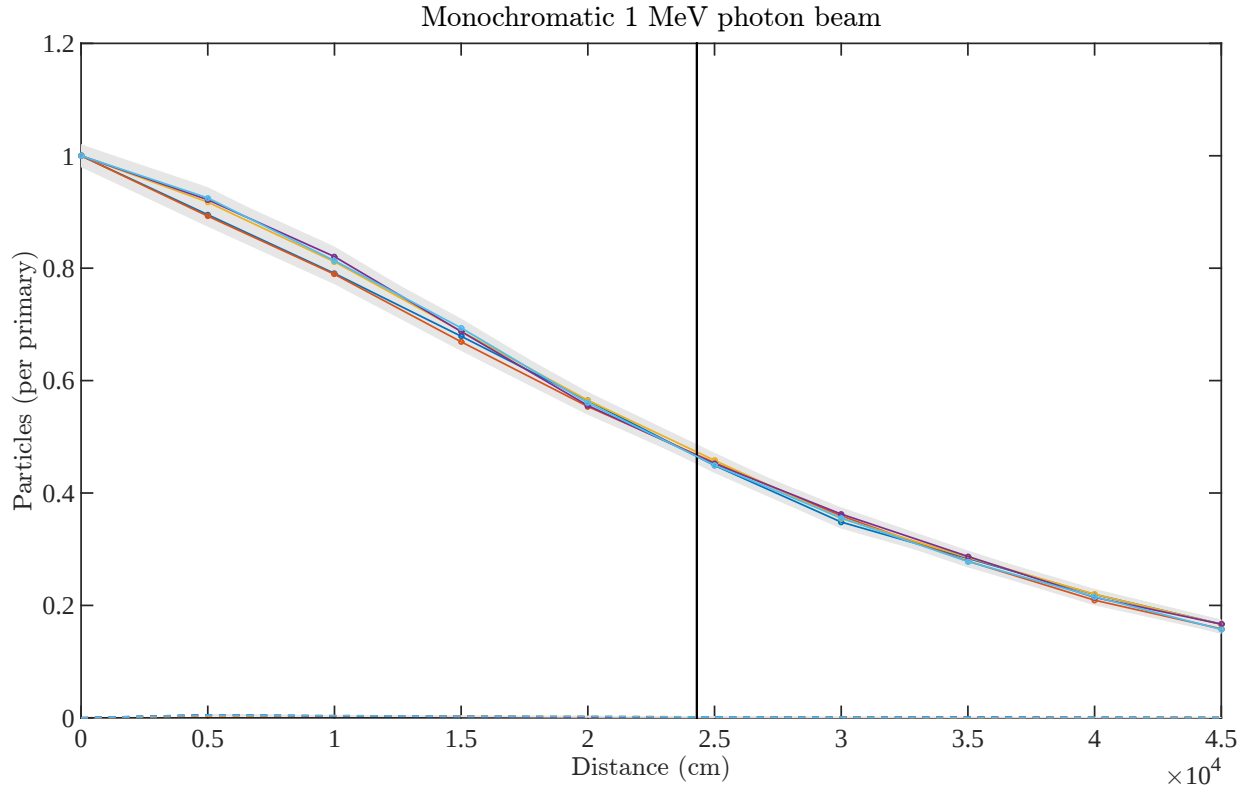


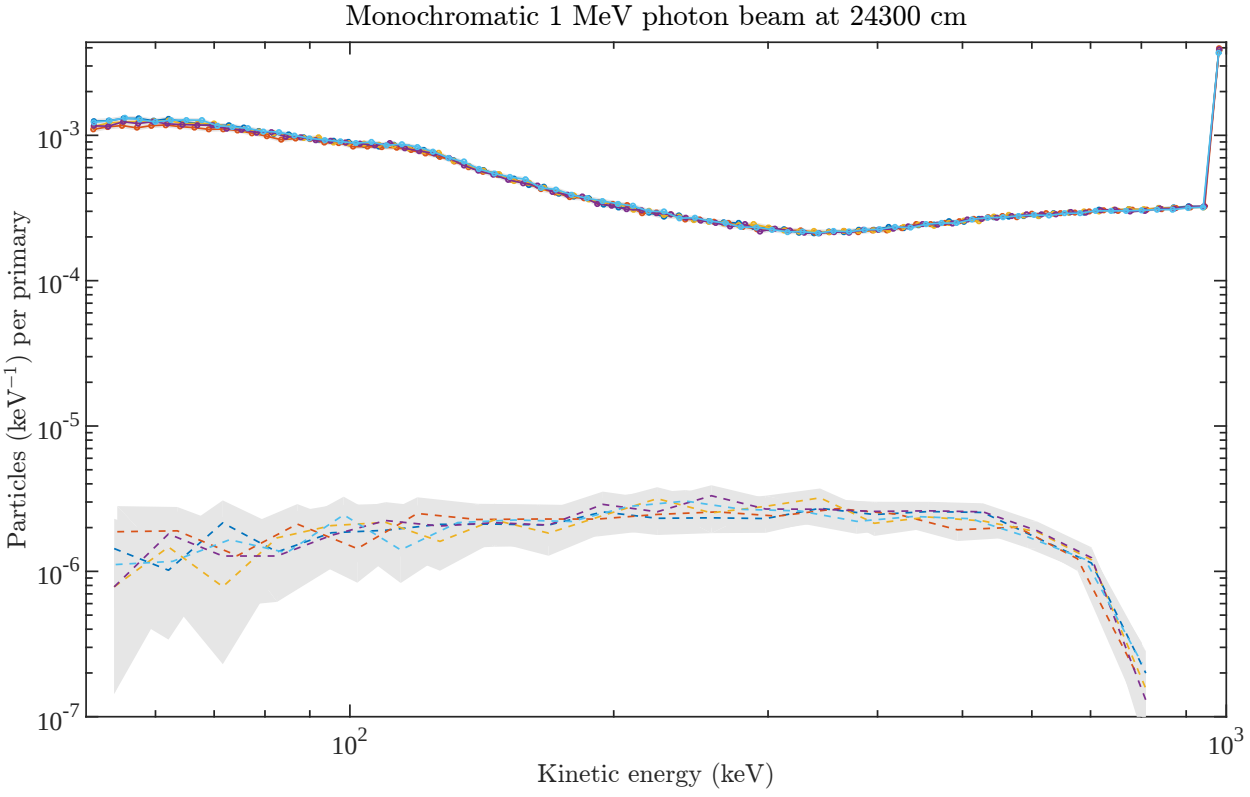


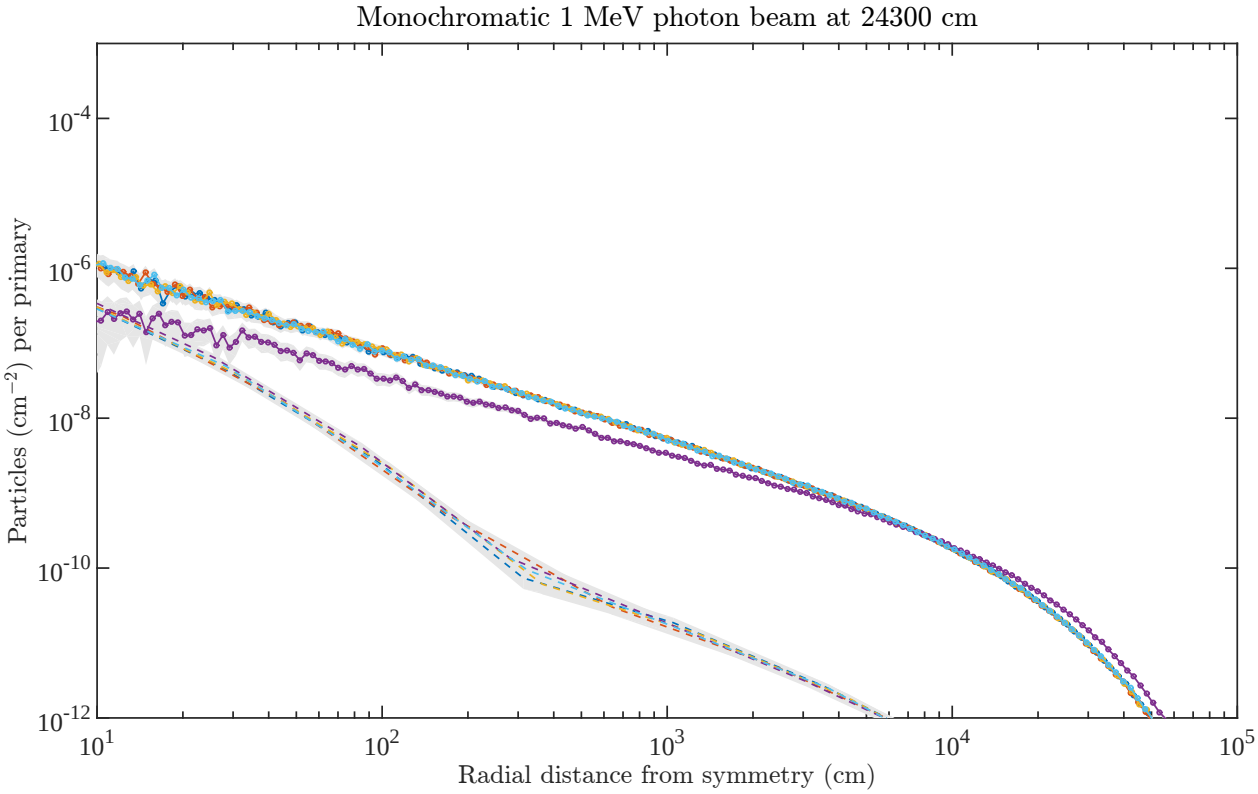

Monochromatic 0.4 MeV photon beam at 16200 cm
Particles (cm^{-2}) per primary
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
Radial distance from symmetry (cm)

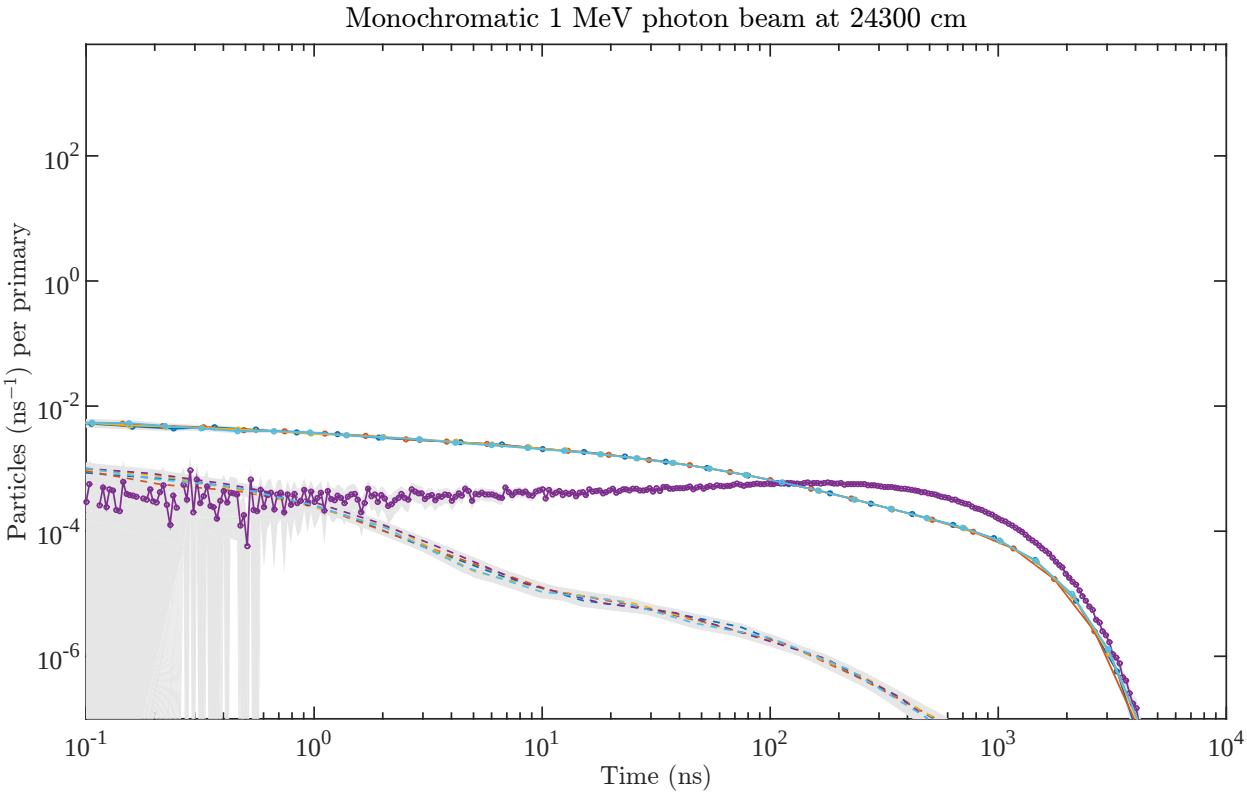

Monochromatic 0.4 MeV photon beam at 16200 cm
Particles (ns^{-1}) per primary
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Time (ns)

2.3 Initial 1.0 MeV kinetic energy, detector distance at 24300 cm

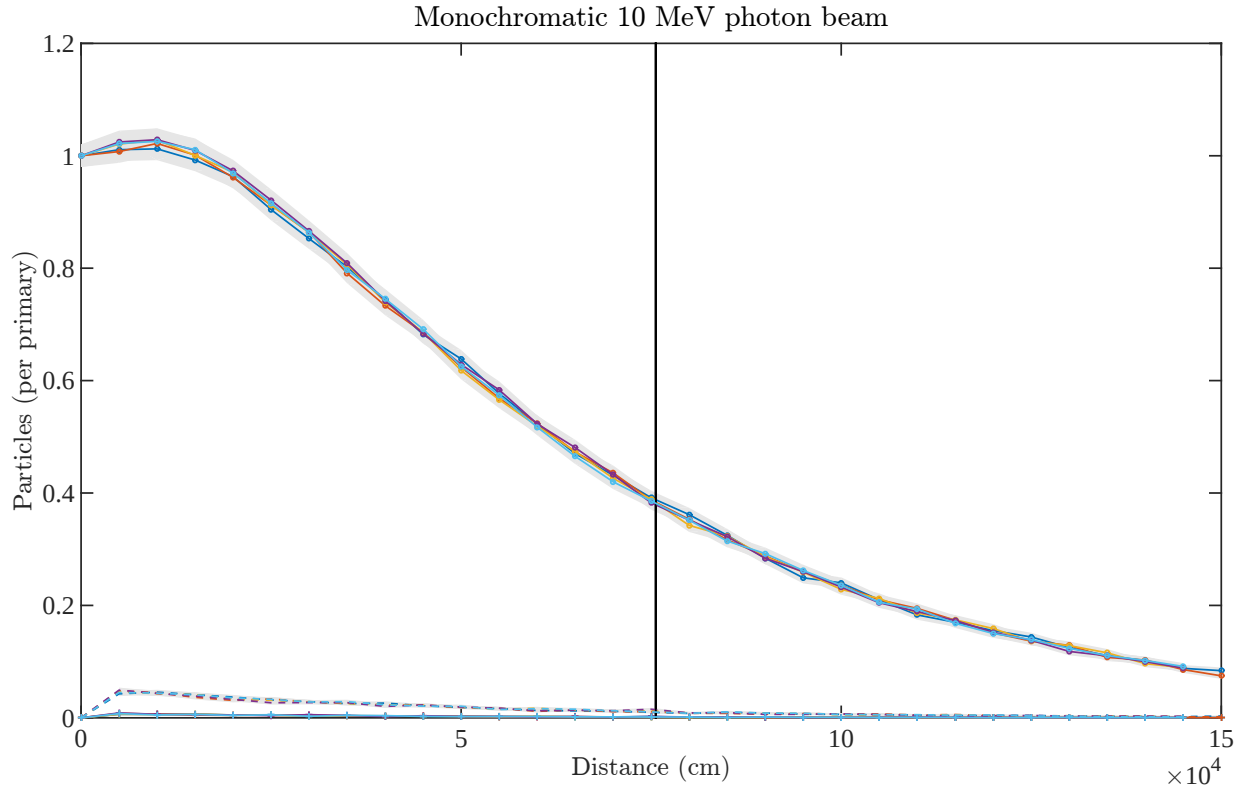


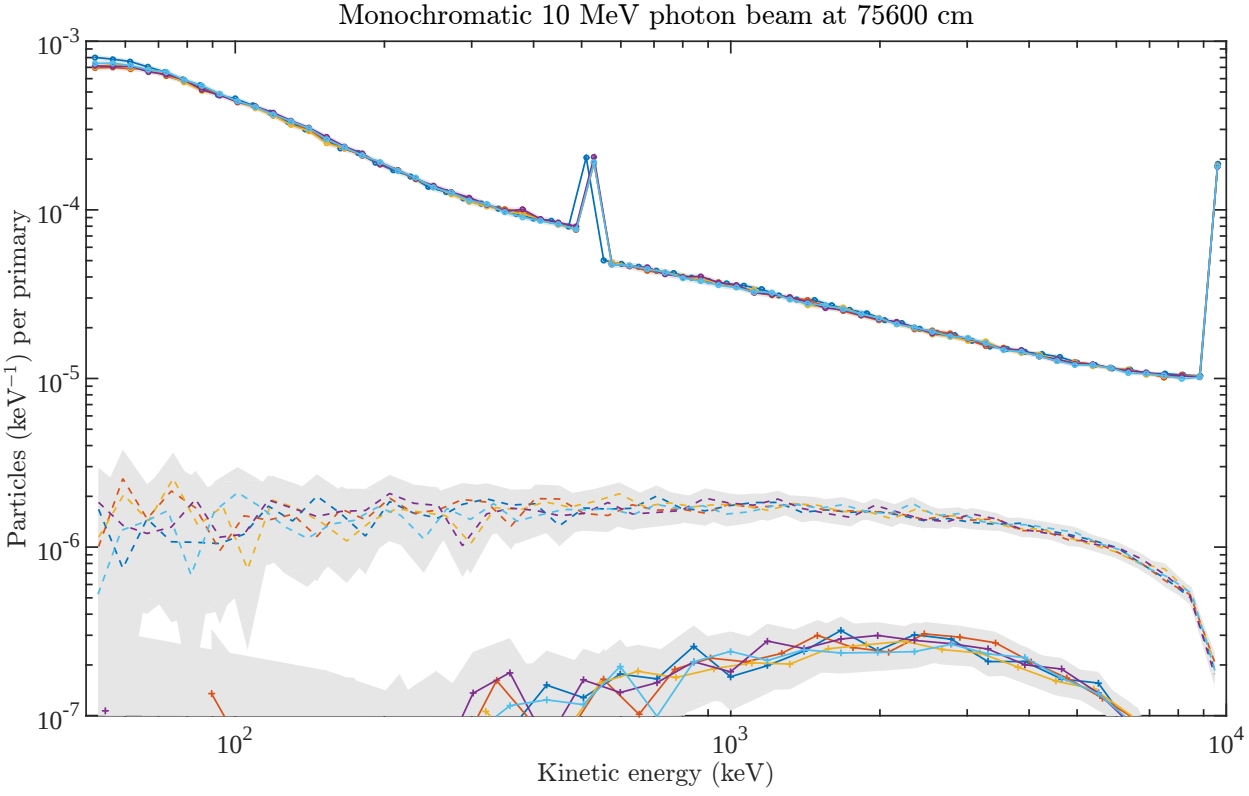


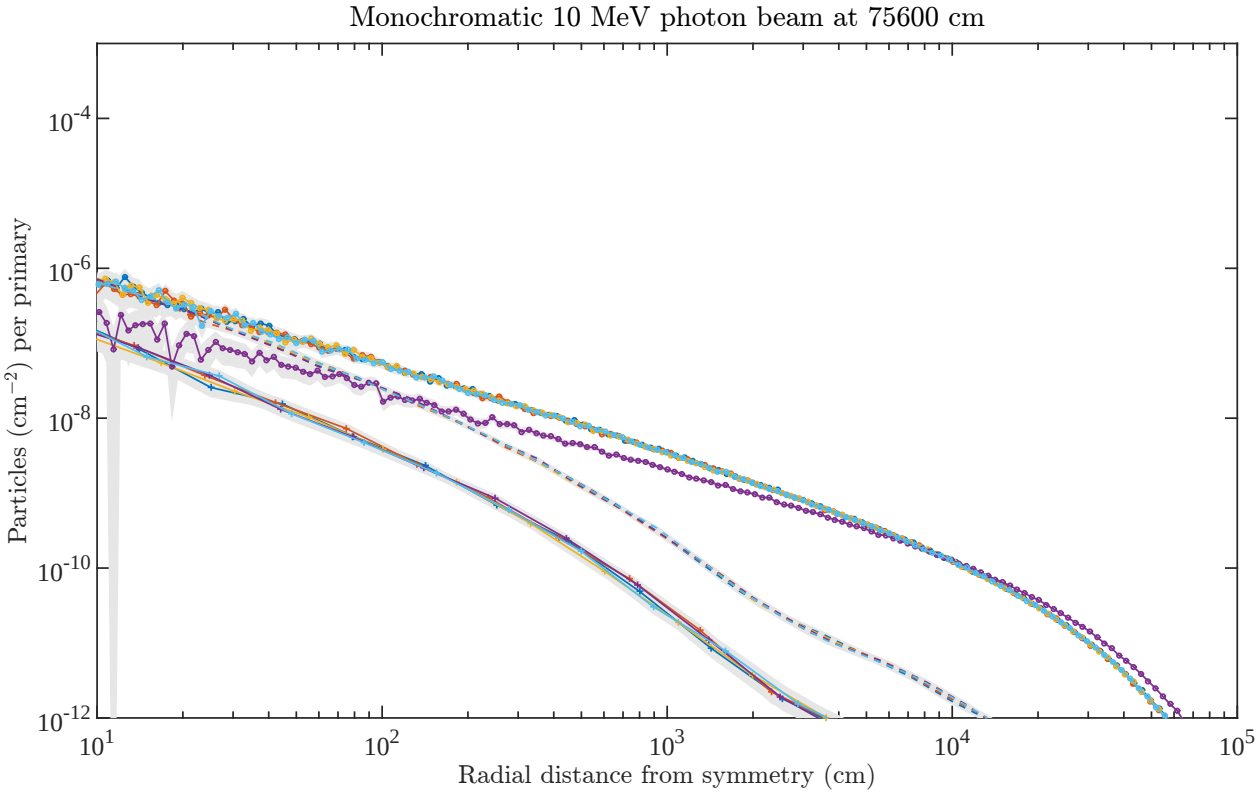

Monochromatic 1 MeV photon beam at 24300 cm
Particles (cm^{-2}) per primary
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
Radial distance from symmetry (cm)

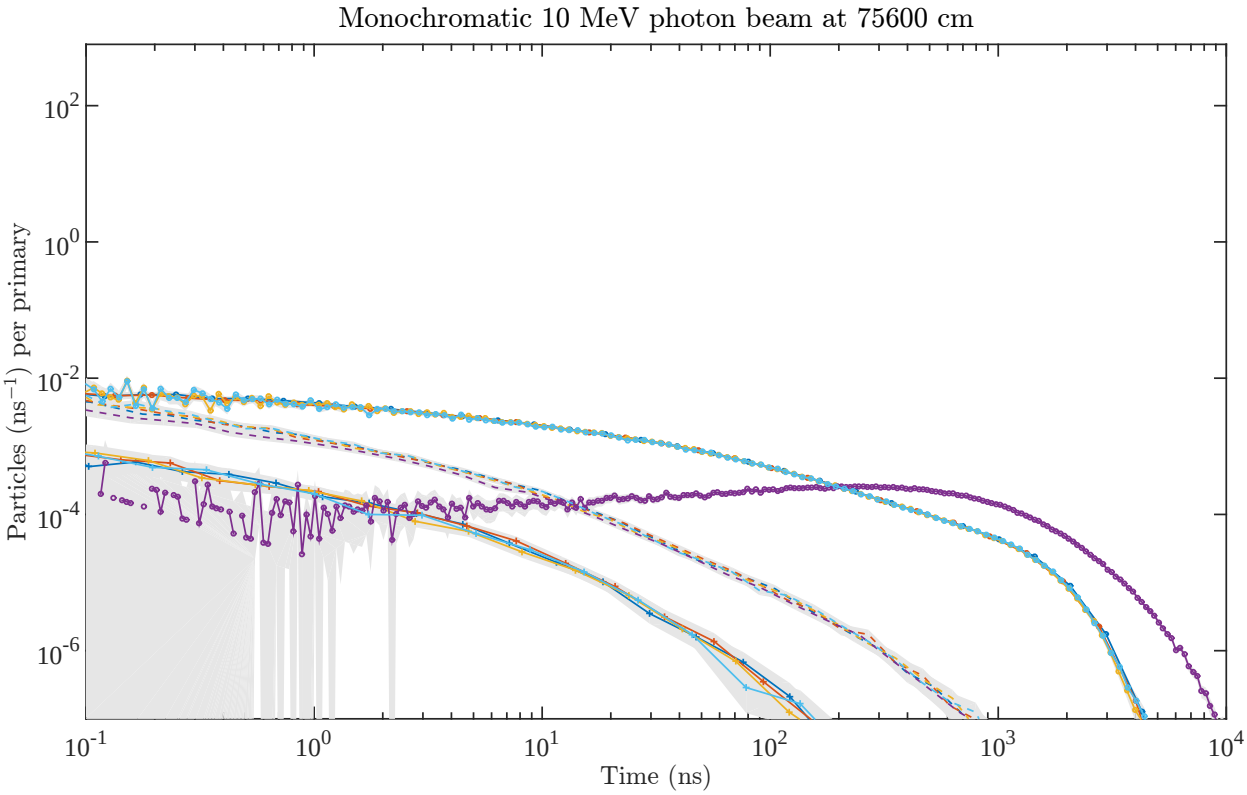

Monochromatic 1 MeV photon beam at 24300 cm
Particles (ns^{-1}) per primary
10^{2}
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Time (ns)

2.4 Initial 10 MeV kinetic energy, detector distance at 75600 cm

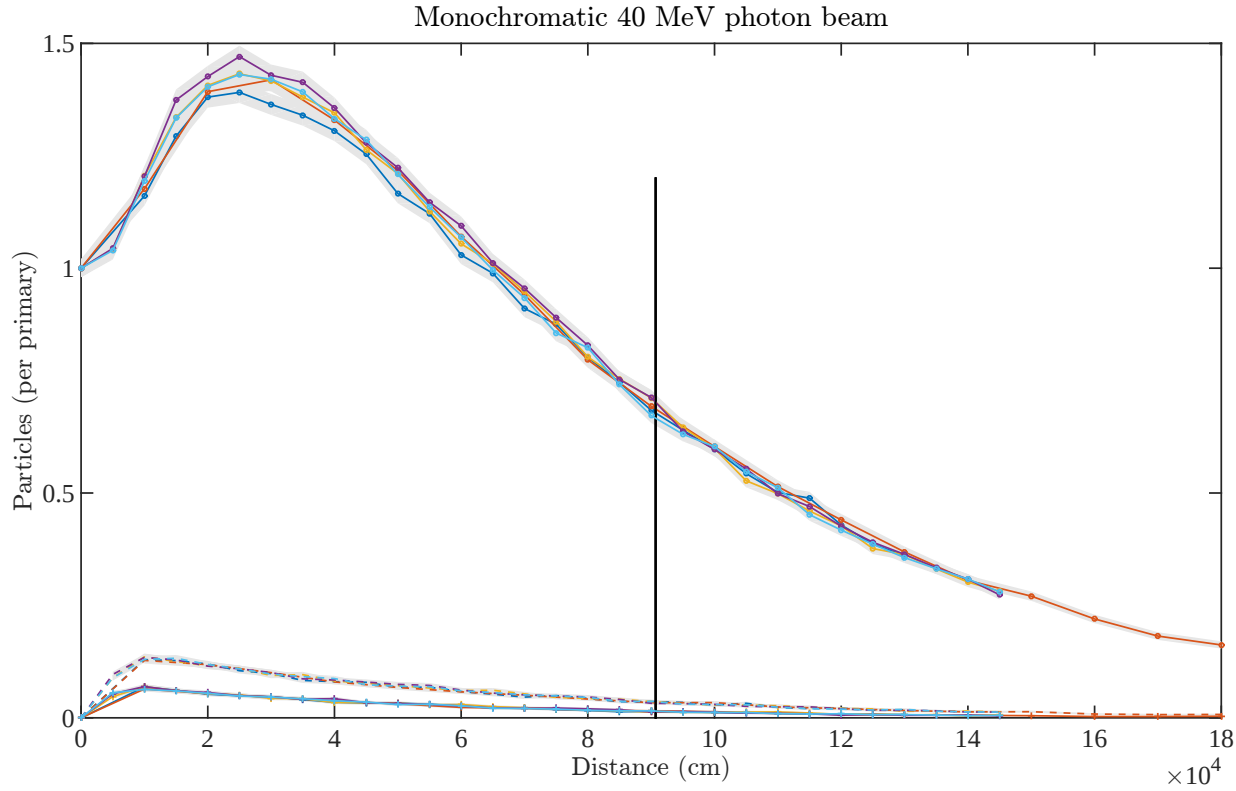


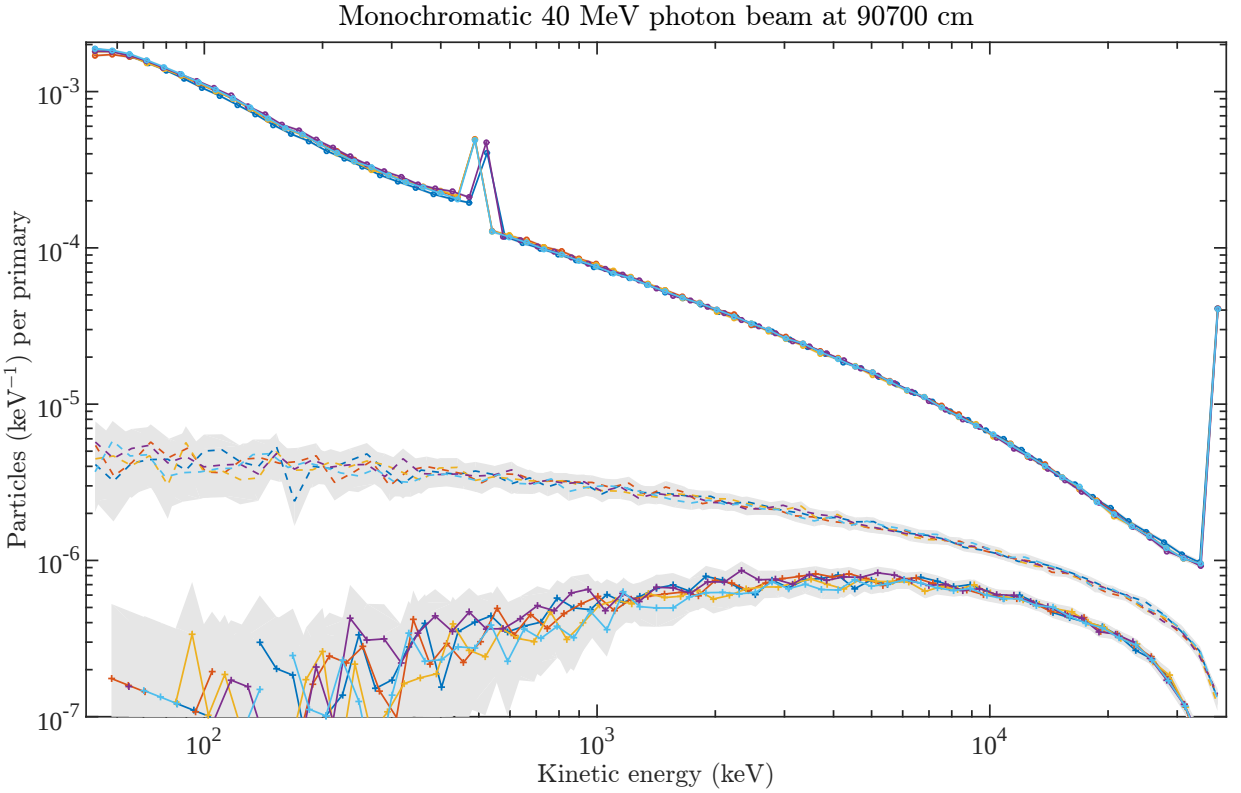


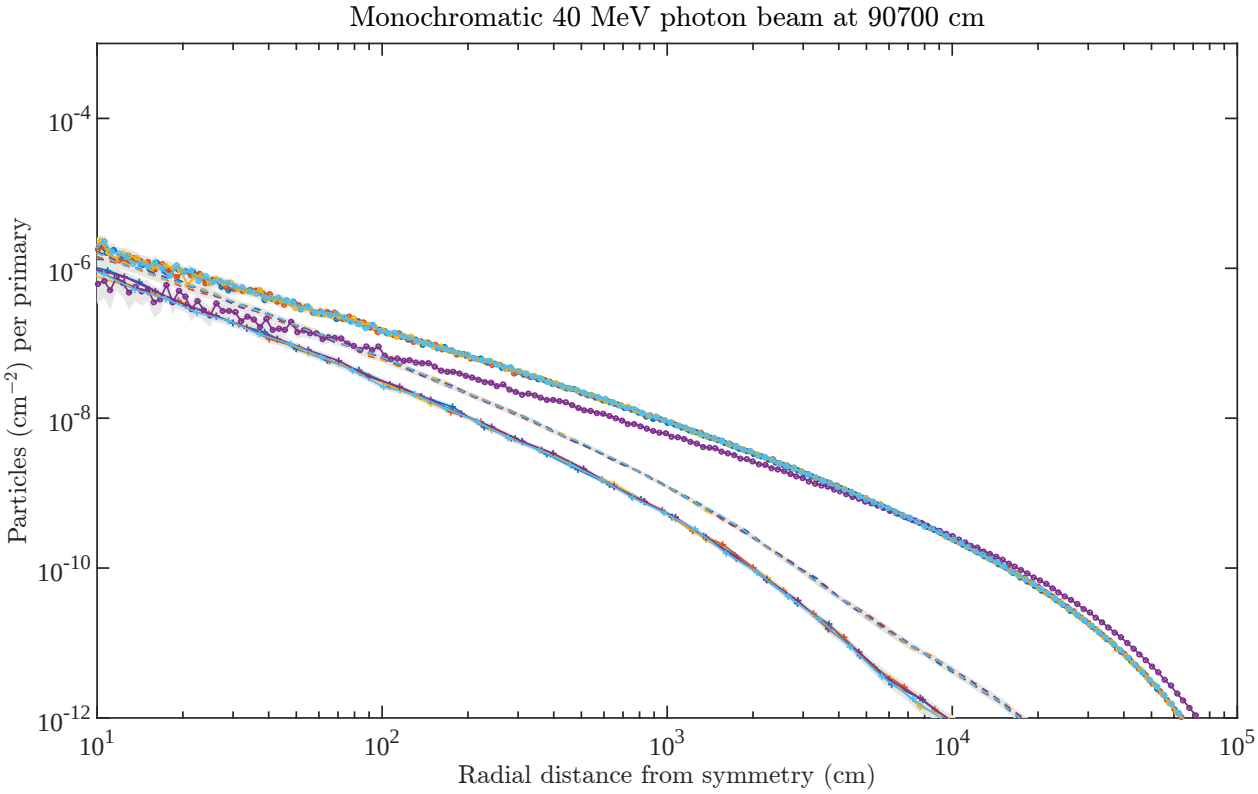

Monochromatic 10 MeV photon beam at 75600 cm
Particles (cm^{-2}) per primary
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
Radial distance from symmetry (cm)

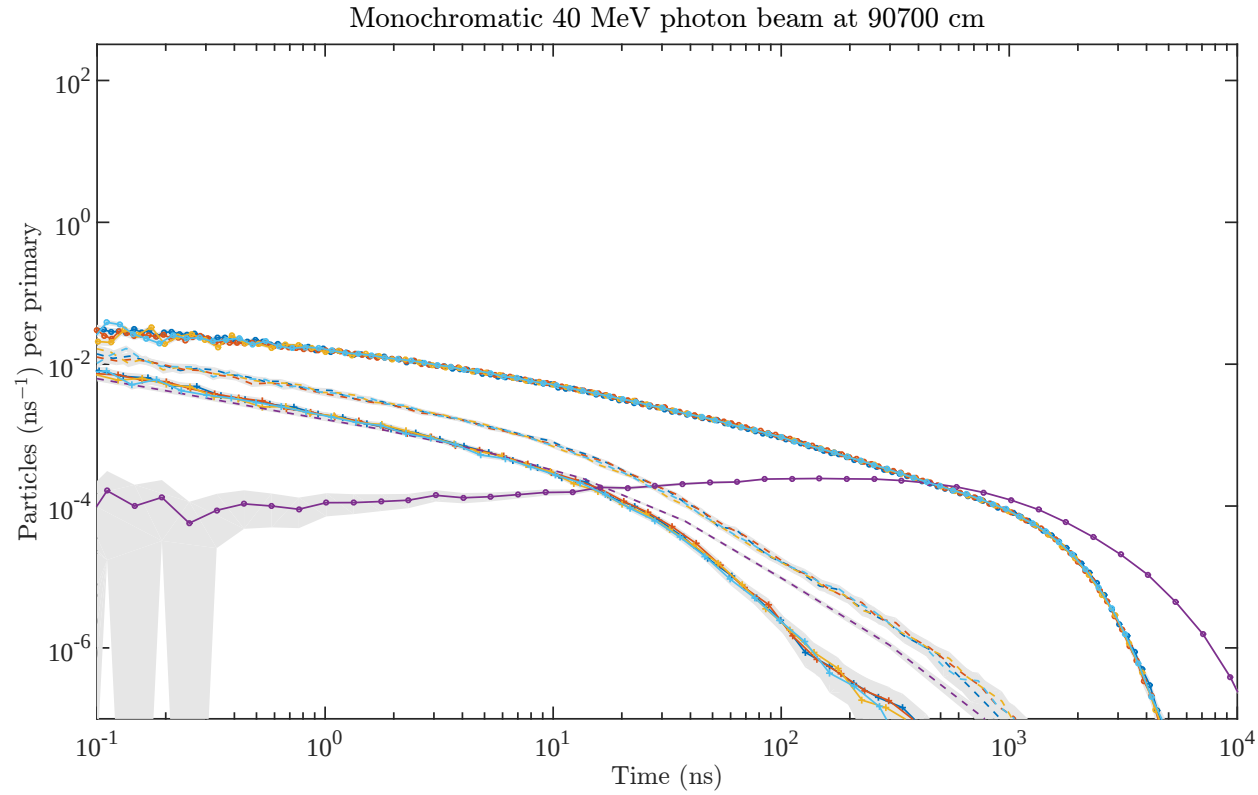

Monochromatic 10 MeV photon beam at 75600 cm
Particles (ns^{-1}) per primary
10^{2}
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Time (ns)

2.5 Initial 40 MeV kinetic energy, detector distance at 90700 cm



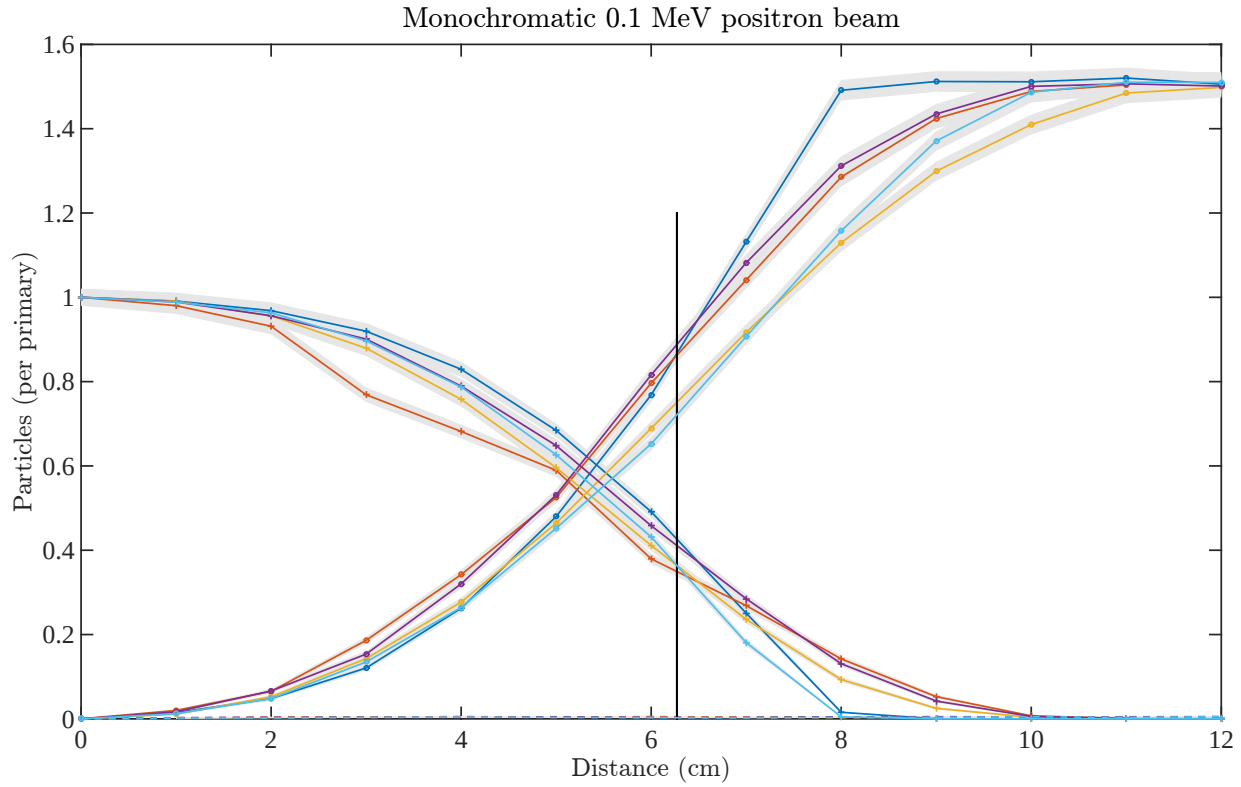


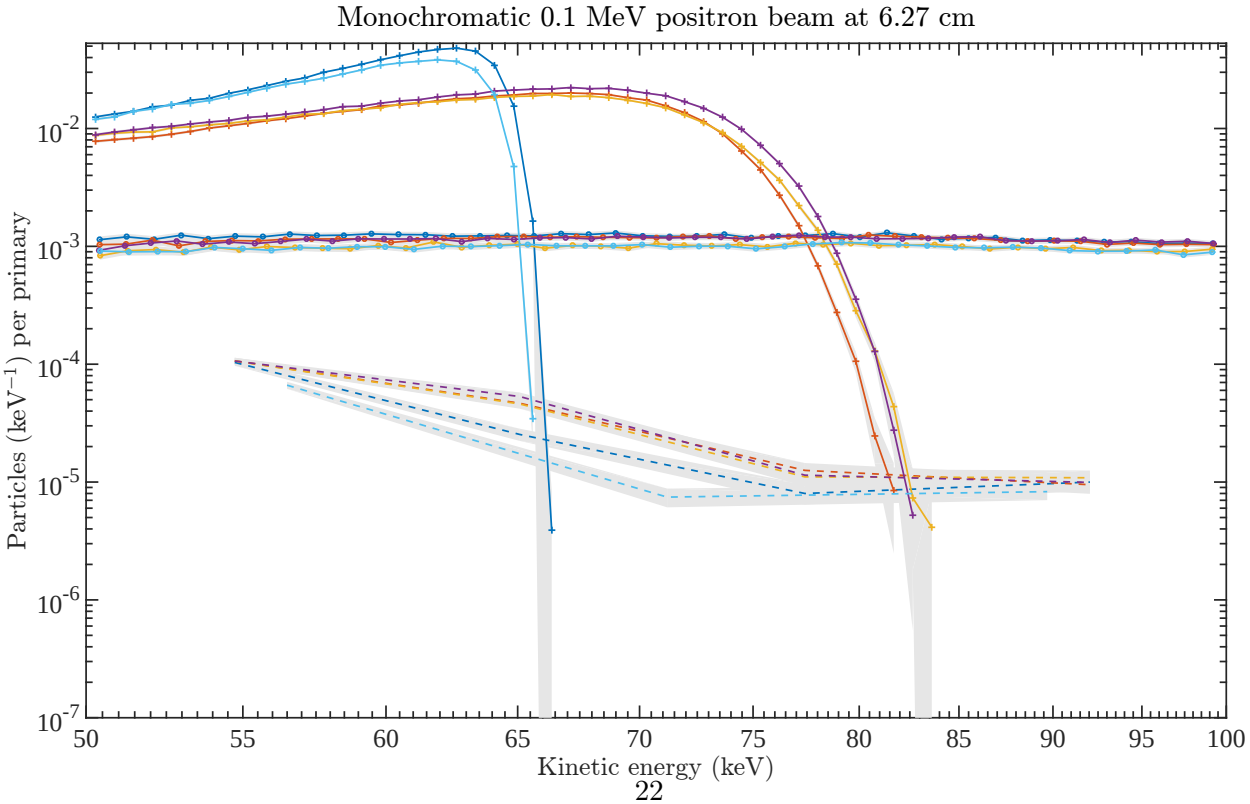

Monochromatic 40 MeV photon beam at 90700 cm
Particles (cm^{-2}) per primary
Radial distance from symmetry (cm)
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}

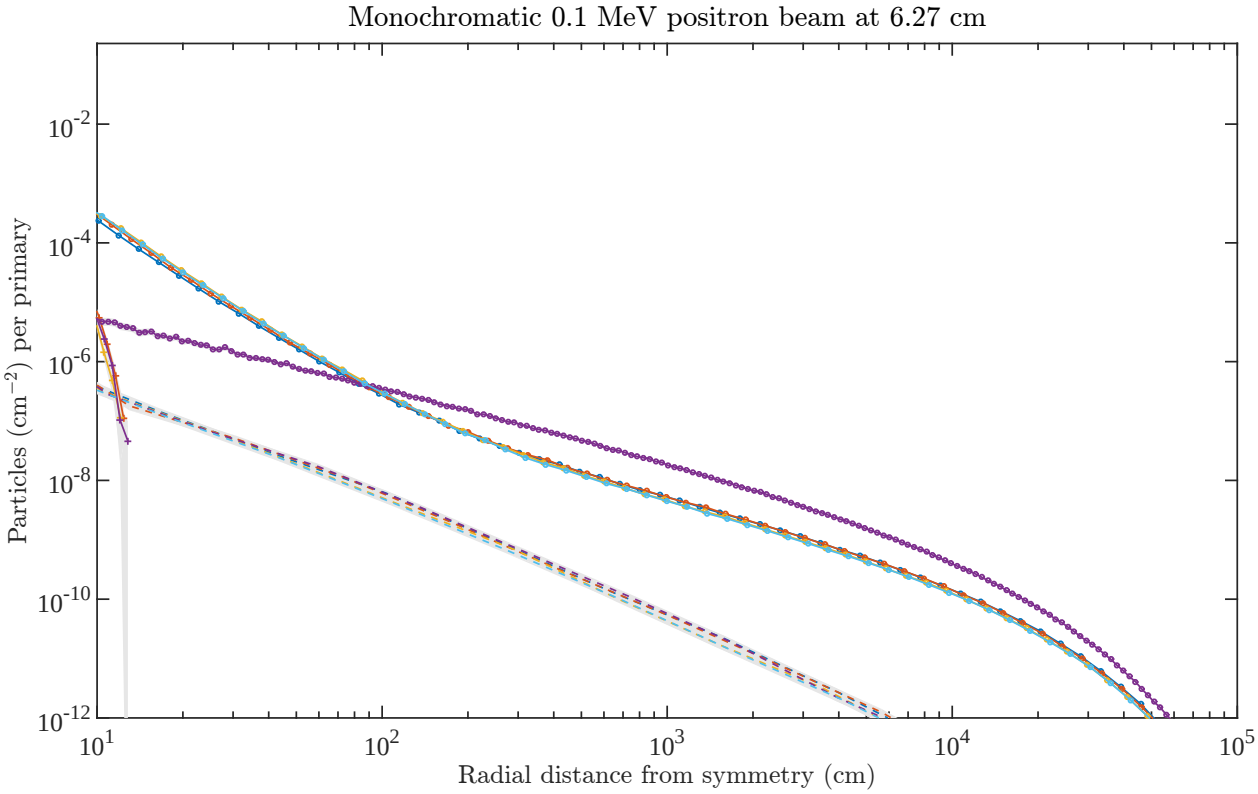

Monochromatic 40 MeV photon beam at 90700 cm
Particles (ns^{-1}) per primary
Time (ns)
10^{2}
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}

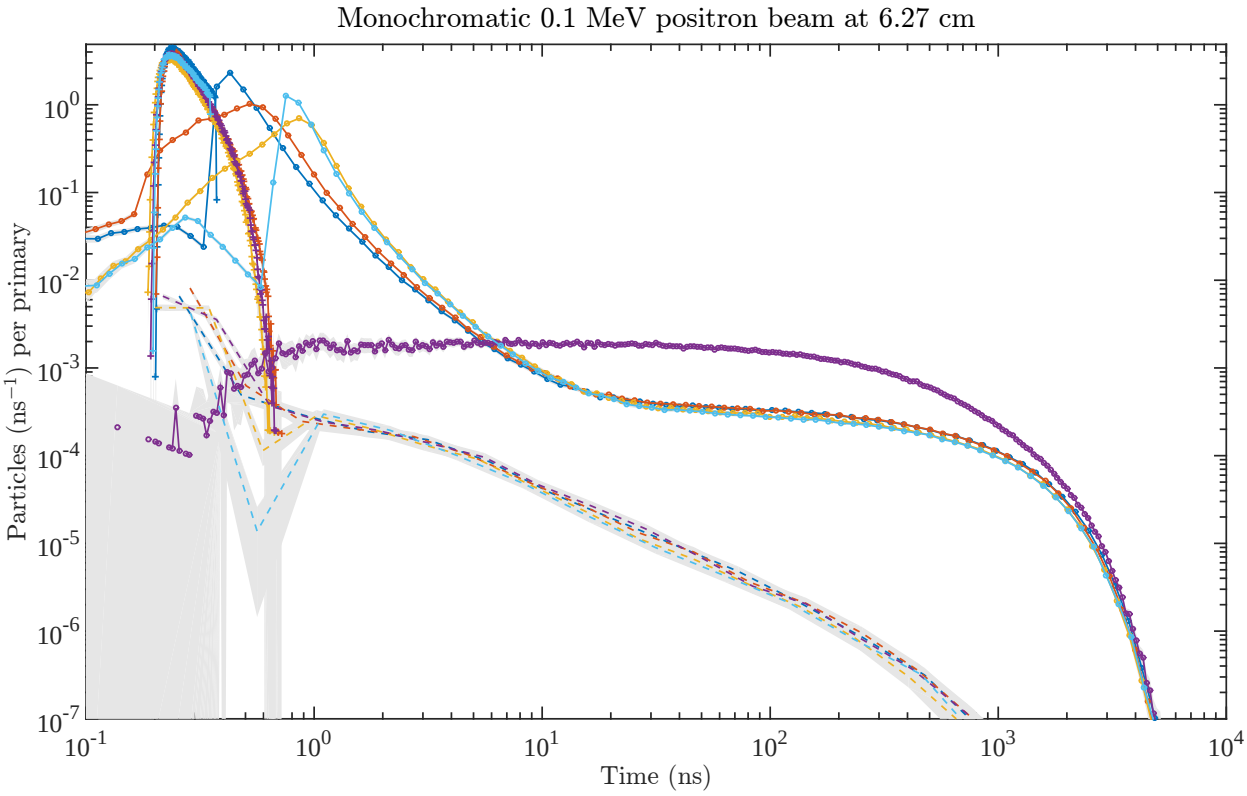
3 Monochromatic positron beams

3.1 Initial 0.1 MeV kinetic energy, detector distance at 6.27 cm

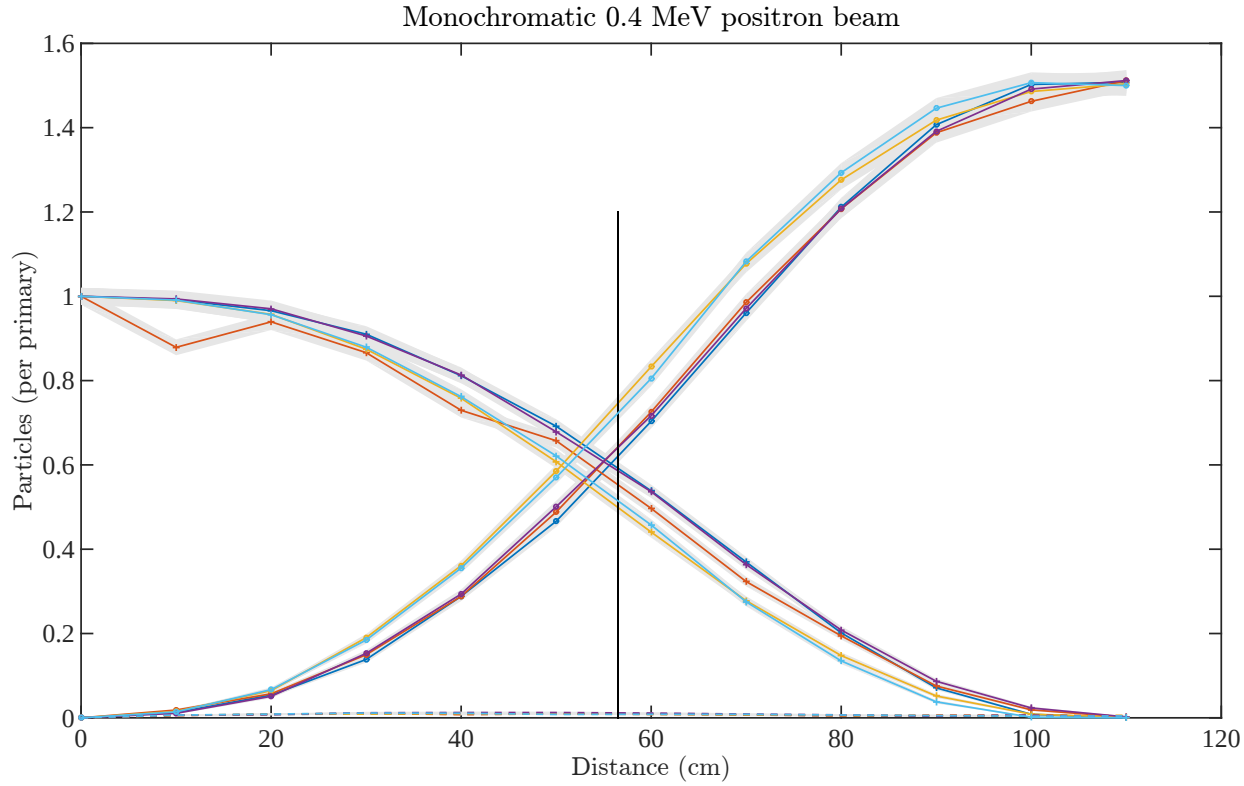


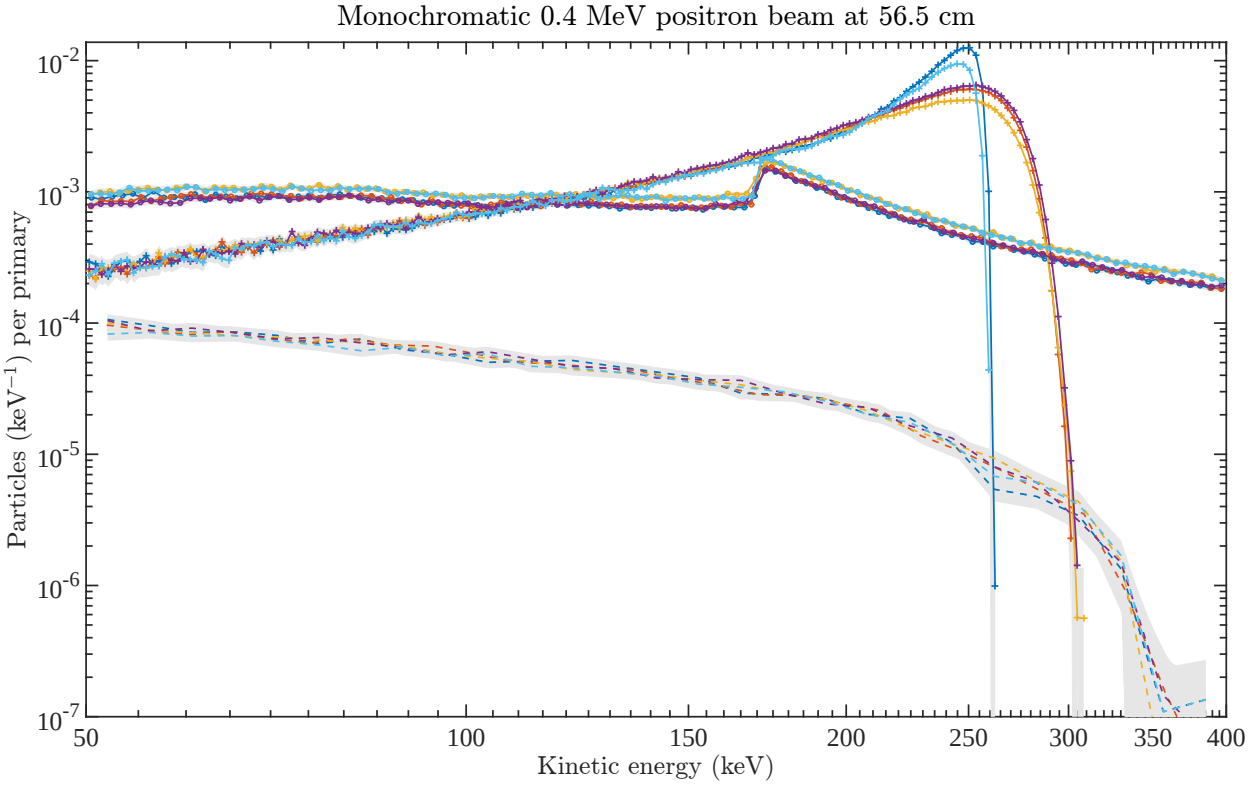


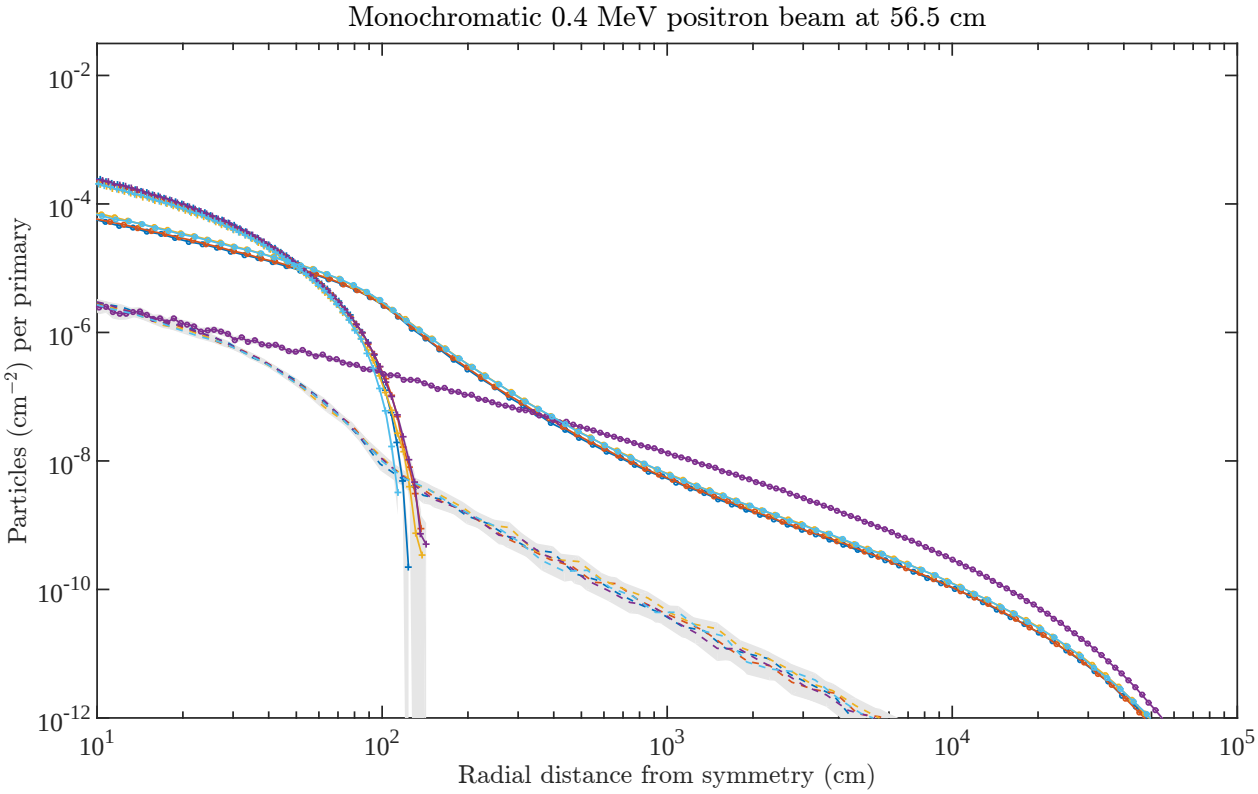

Monochromatic 0.1 MeV positron beam at 6.27 cm
Particles (cm^{-2}) per primary
Radial distance from symmetry (cm)

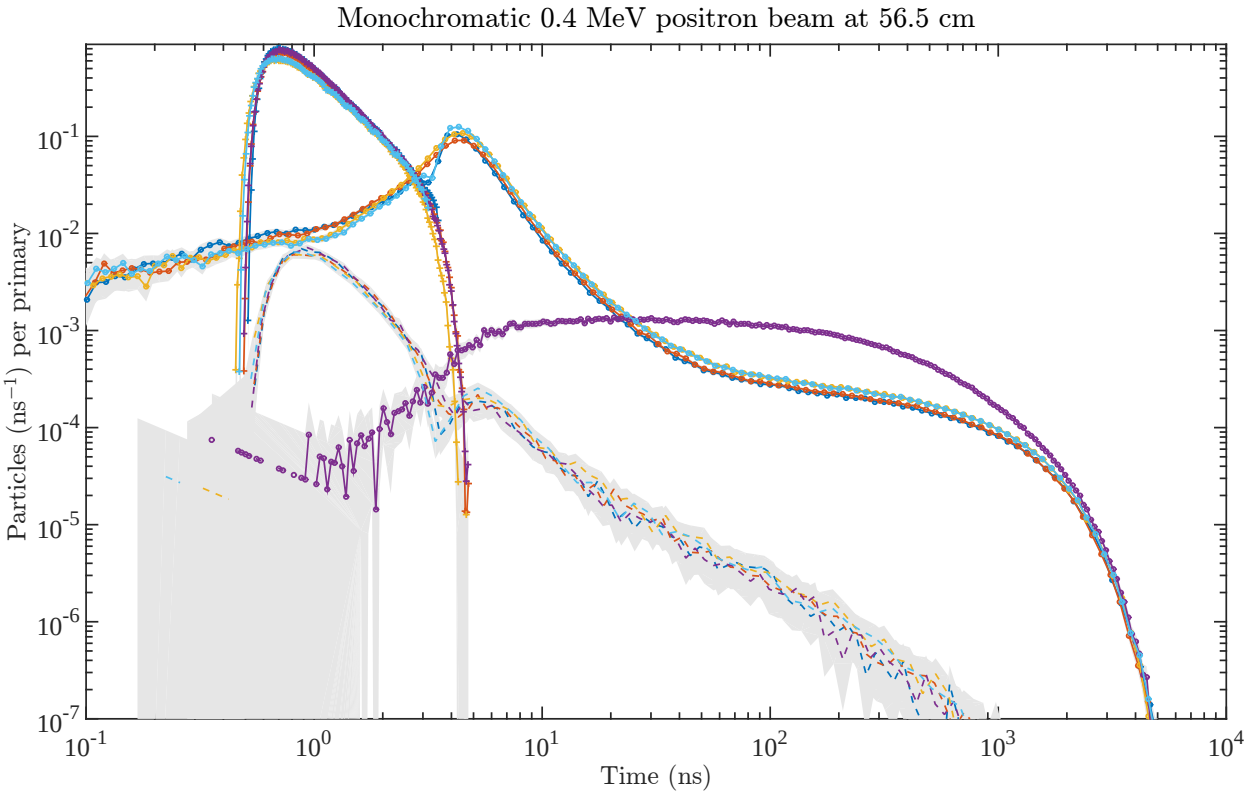

Monochromatic 0.1 MeV positron beam at 6.27 cm
Particles (ns^{-1}) per primary
Time (ns)

3.2 Initial 0.4 MeV kinetic energy, detector distance at 56.5 cm

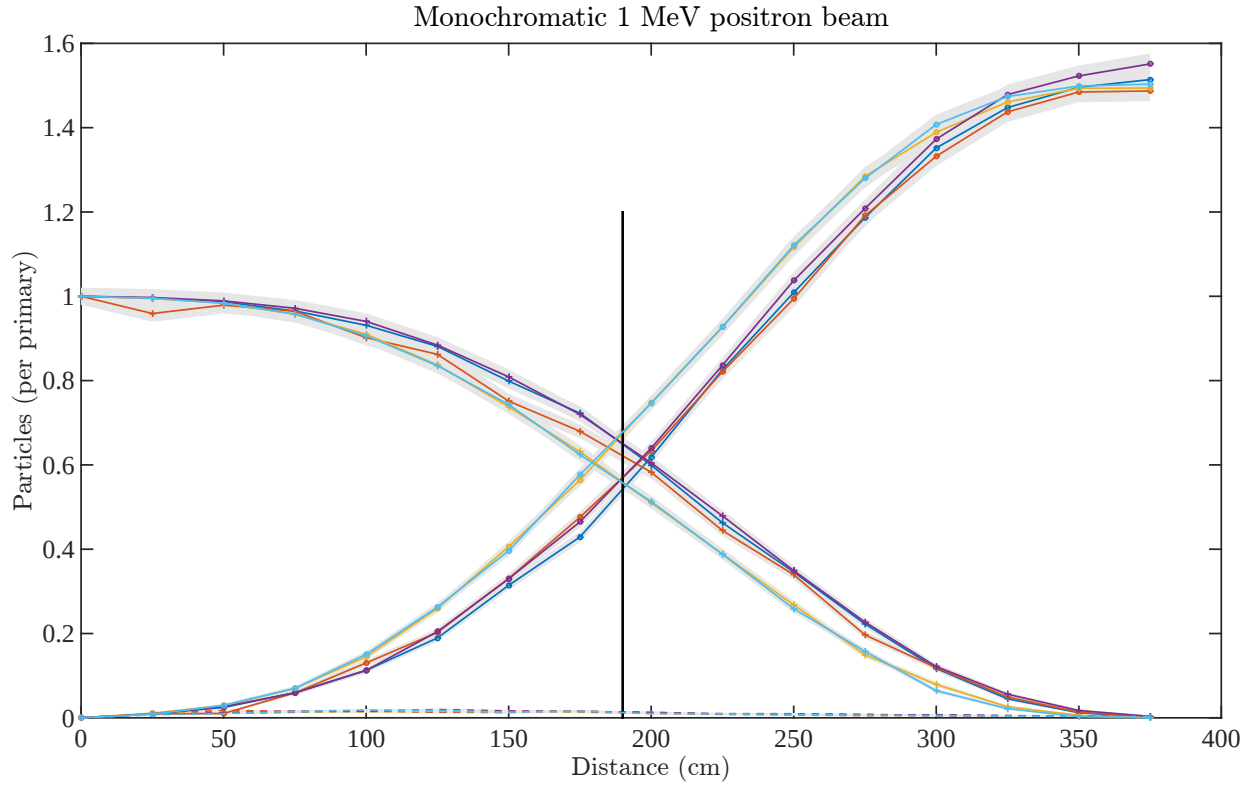


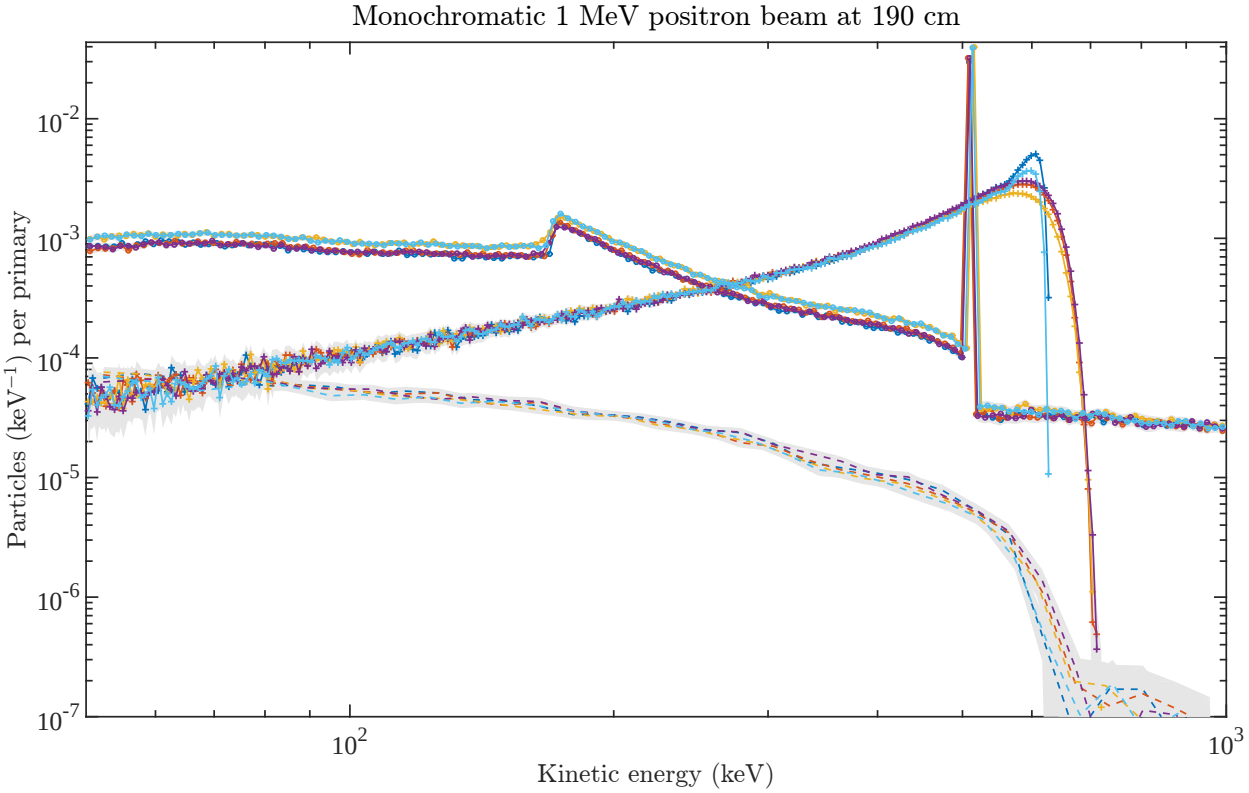


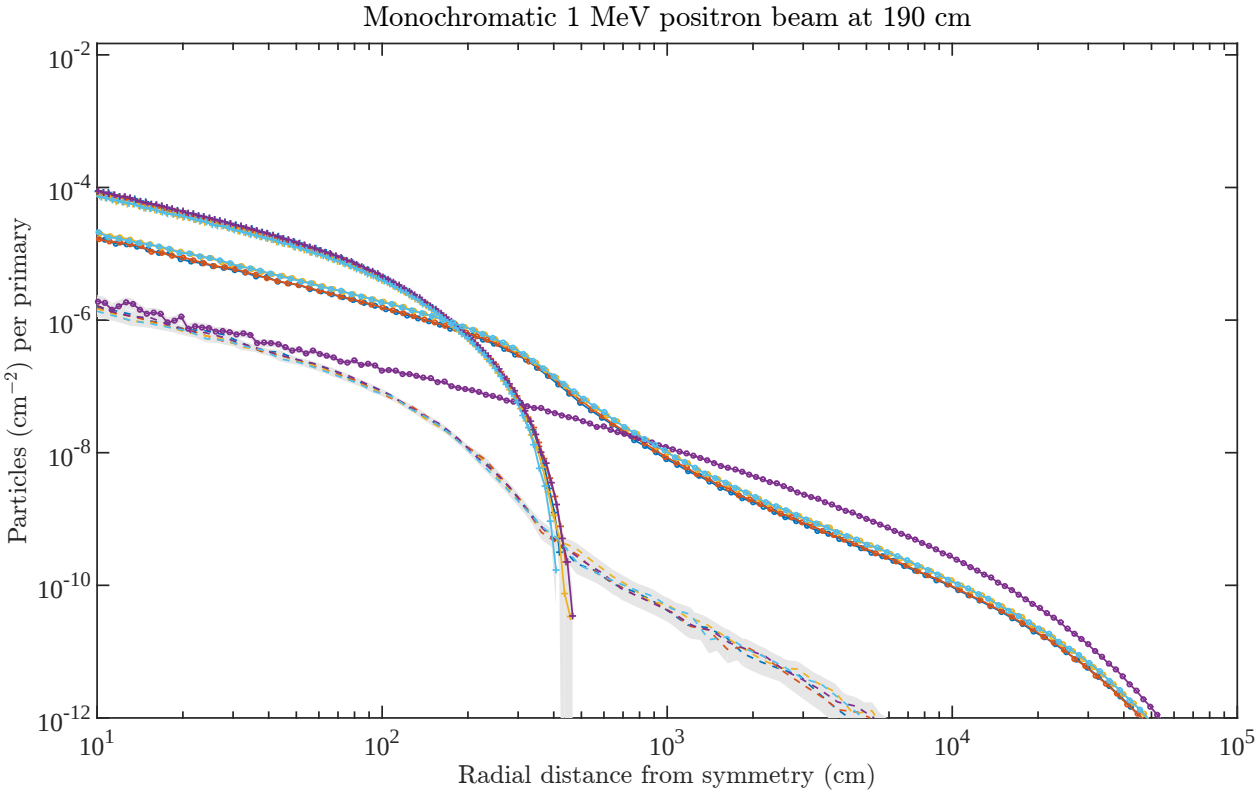

Monochromatic 0.4 MeV positron beam at 56.5 cm
Particles (cm^{-2}) per primary
Radial distance from symmetry (cm)

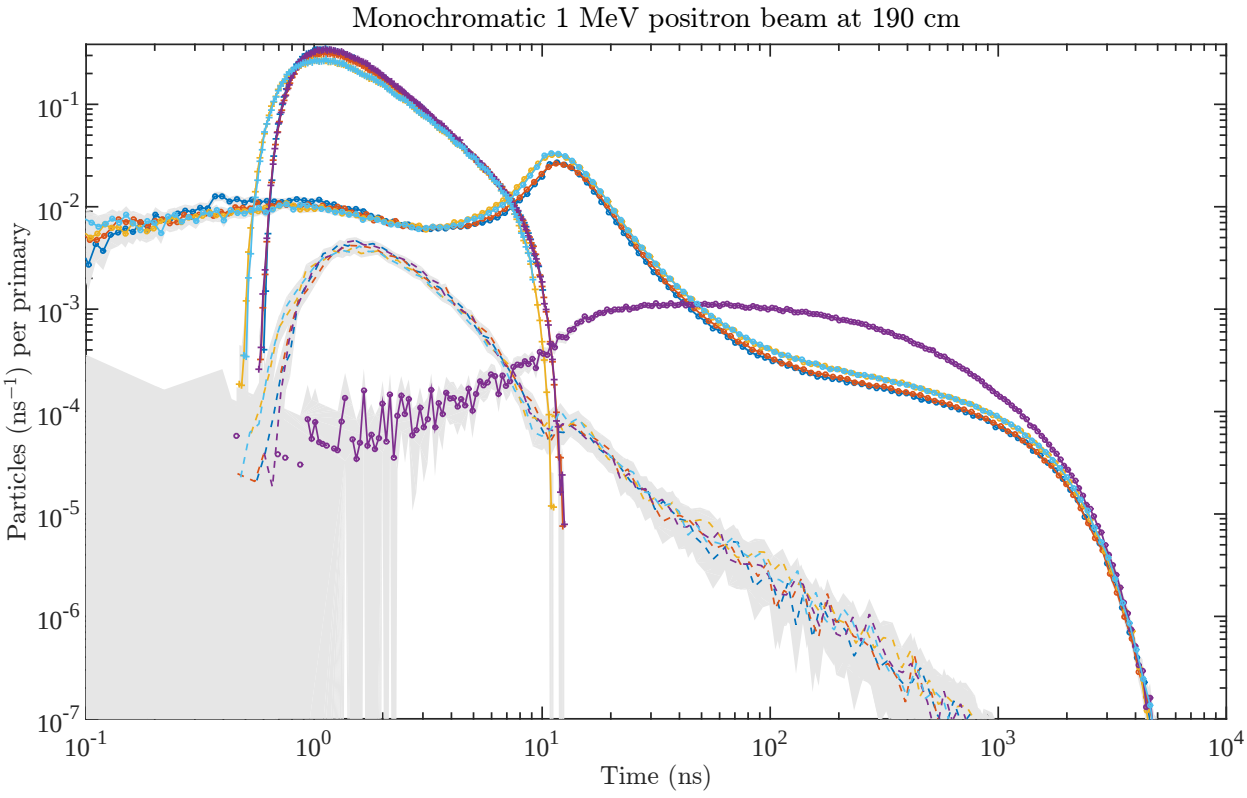

Monochromatic 0.4 MeV positron beam at 56.5 cm
Particles (ns^{-1}) per primary
Time (ns)

3.3 Initial 1.0 MeV kinetic energy, detector distance at 190 cm

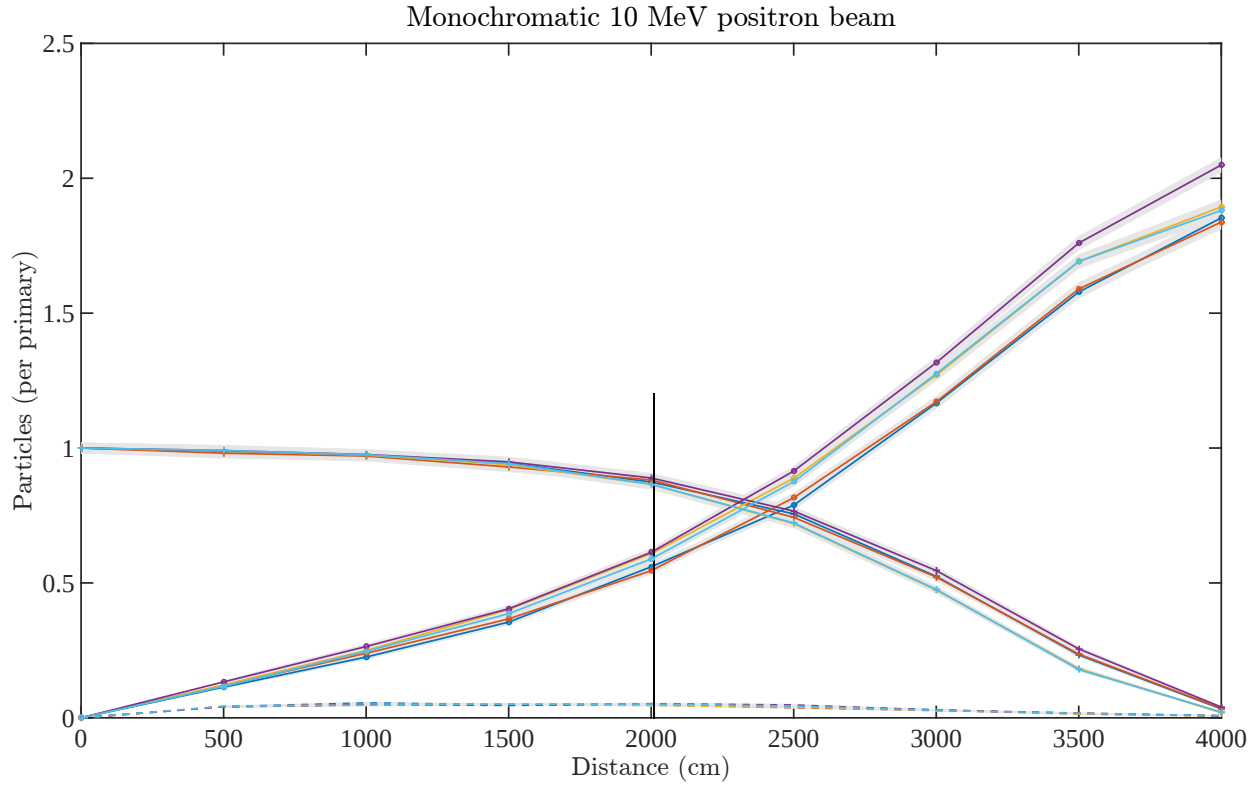


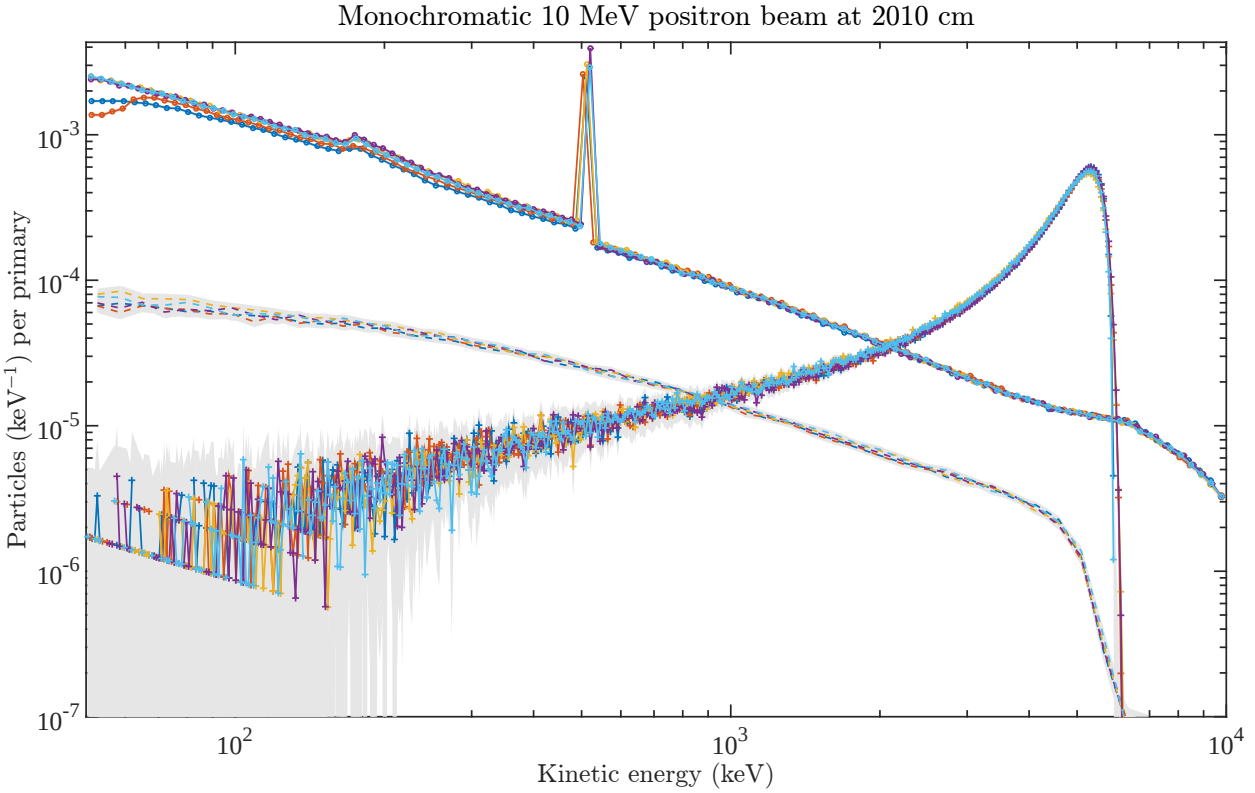


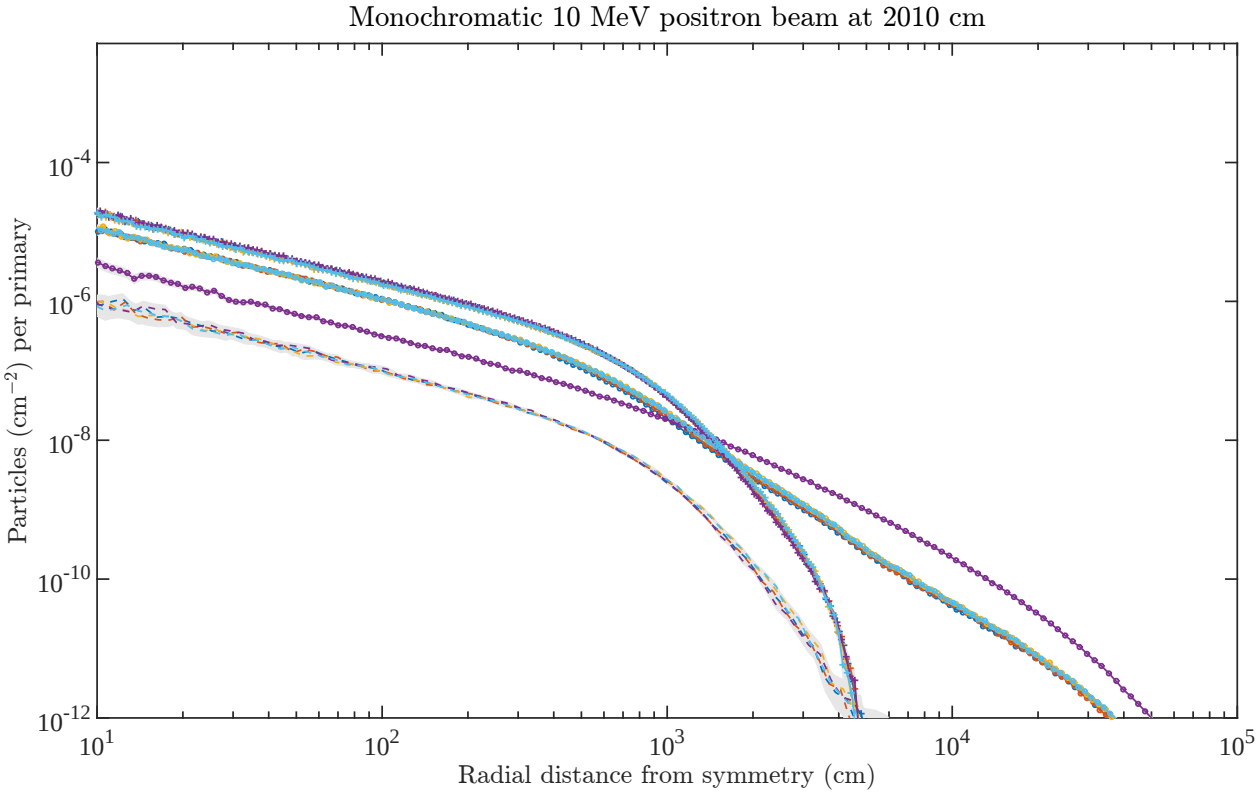

Monochromatic 1 MeV positron beam at 190 cm
Particles (cm^{-2}) per primary
Radial distance from symmetry (cm)

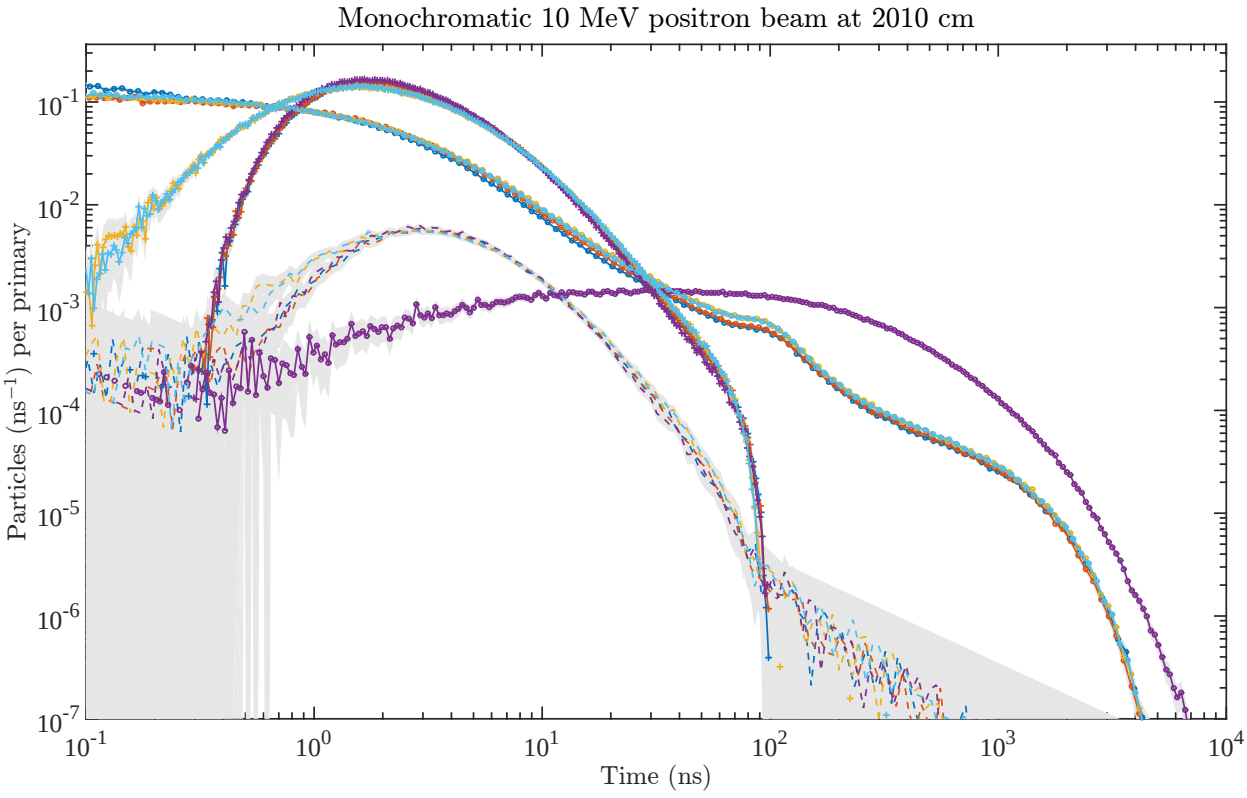

Monochromatic 1 MeV positron beam at 190 cm
Particles (ns^{-1}) per primary
Time (ns)

3.4 Initial 10 MeV kinetic energy, detector distance at 2010 cm

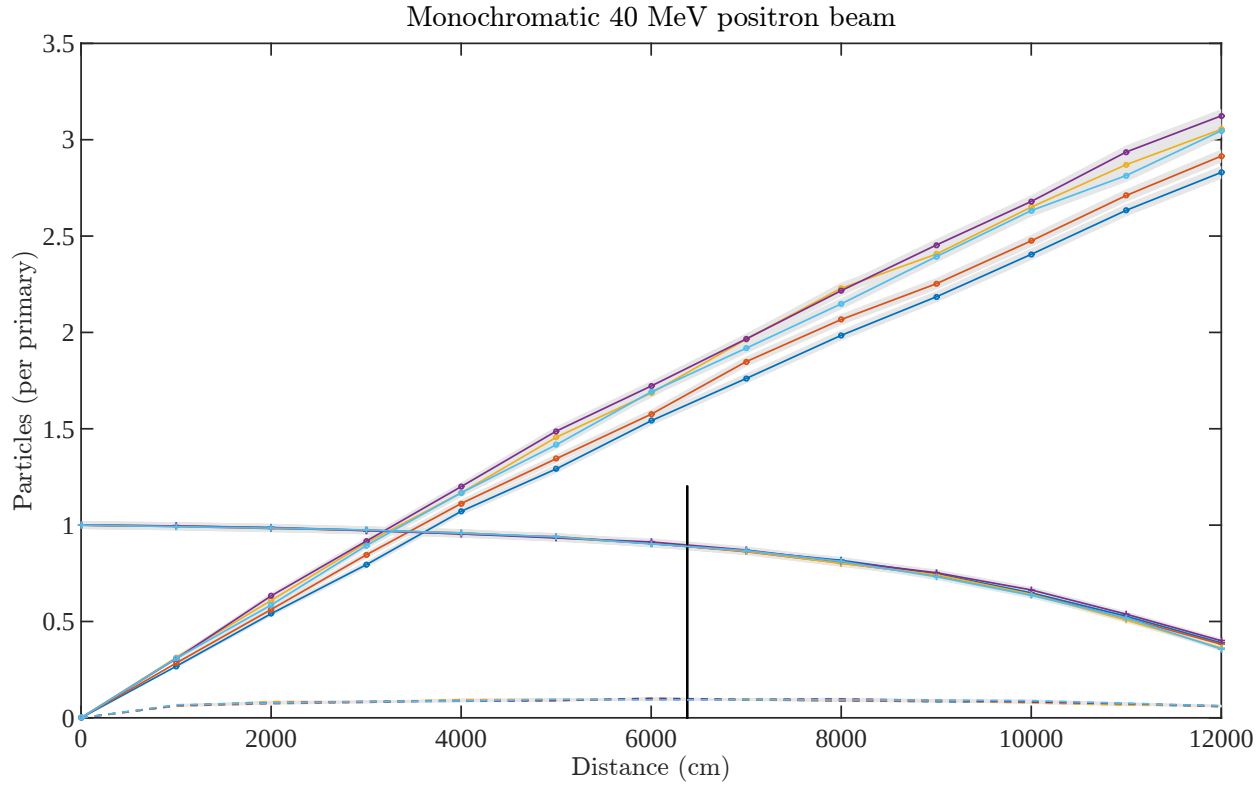


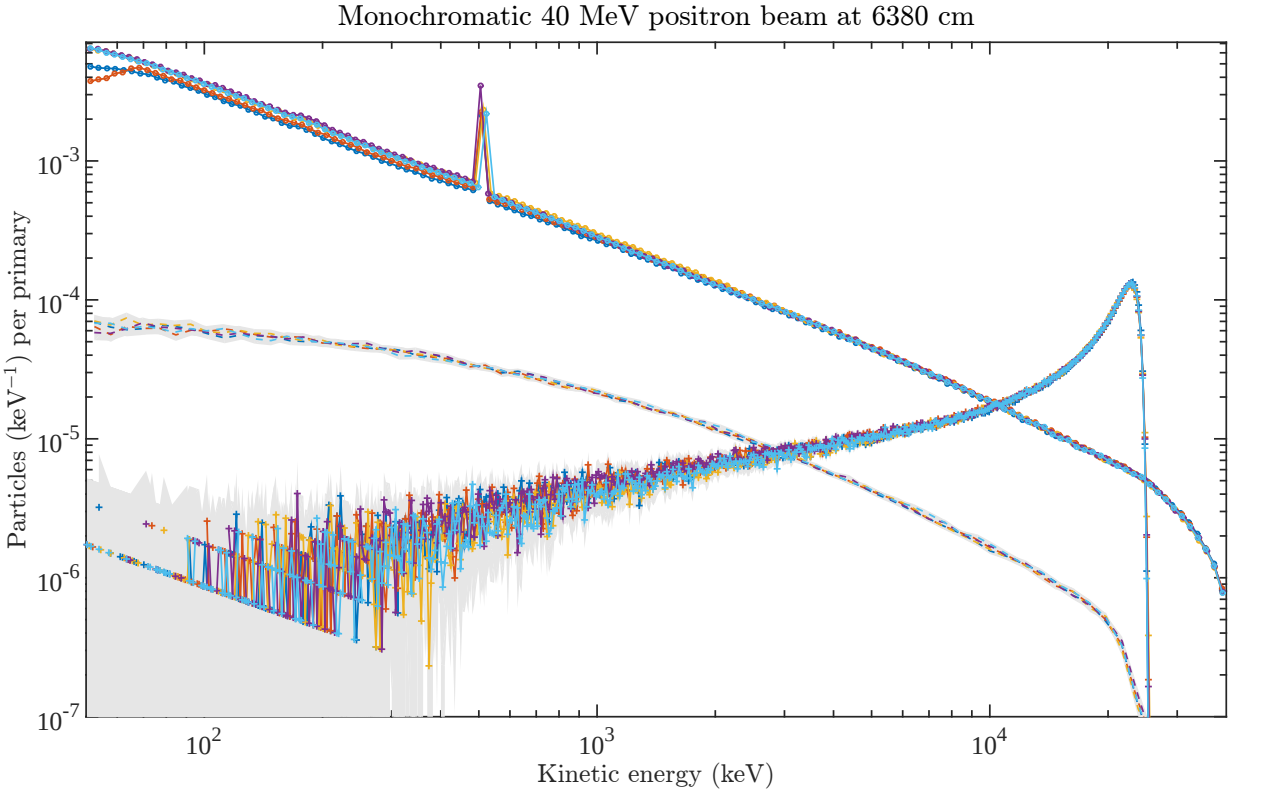


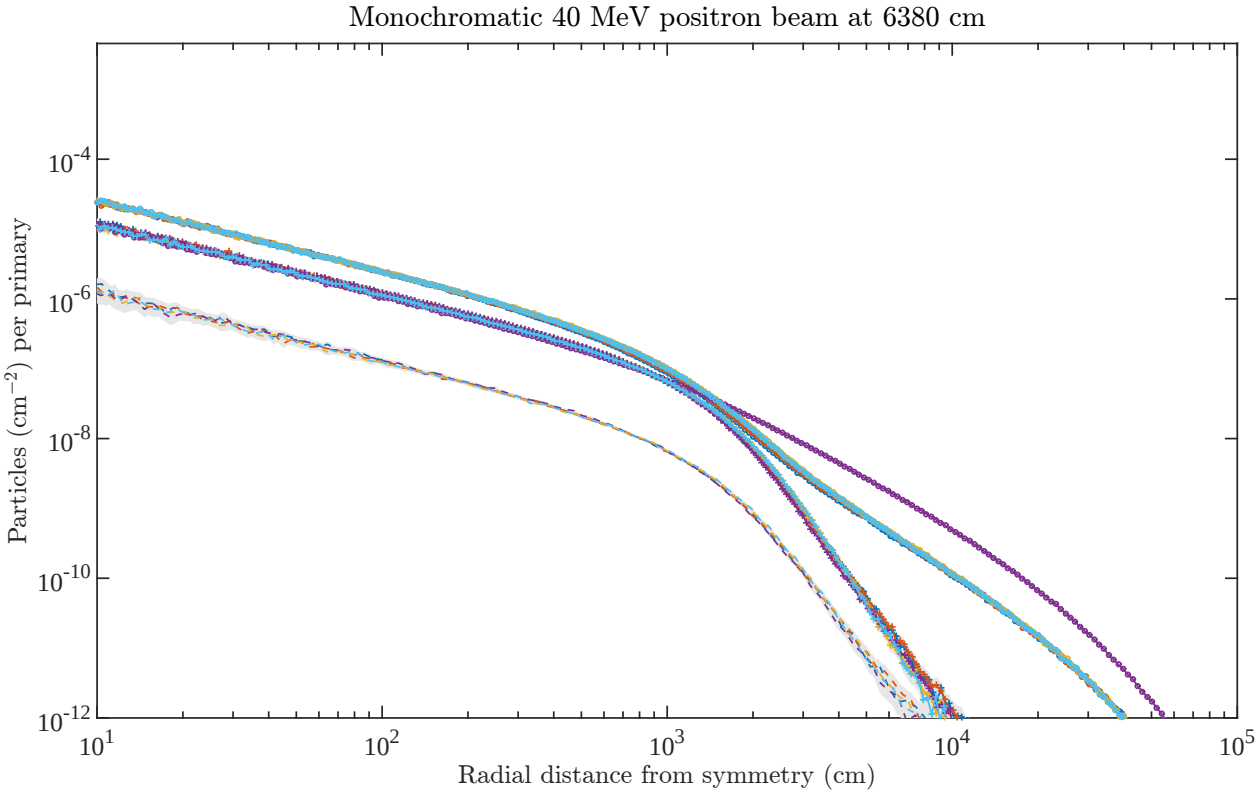

Monochromatic 10 MeV positron beam at 2010 cm
Particles (cm^{-2}) per primary
Radial distance from symmetry (cm)

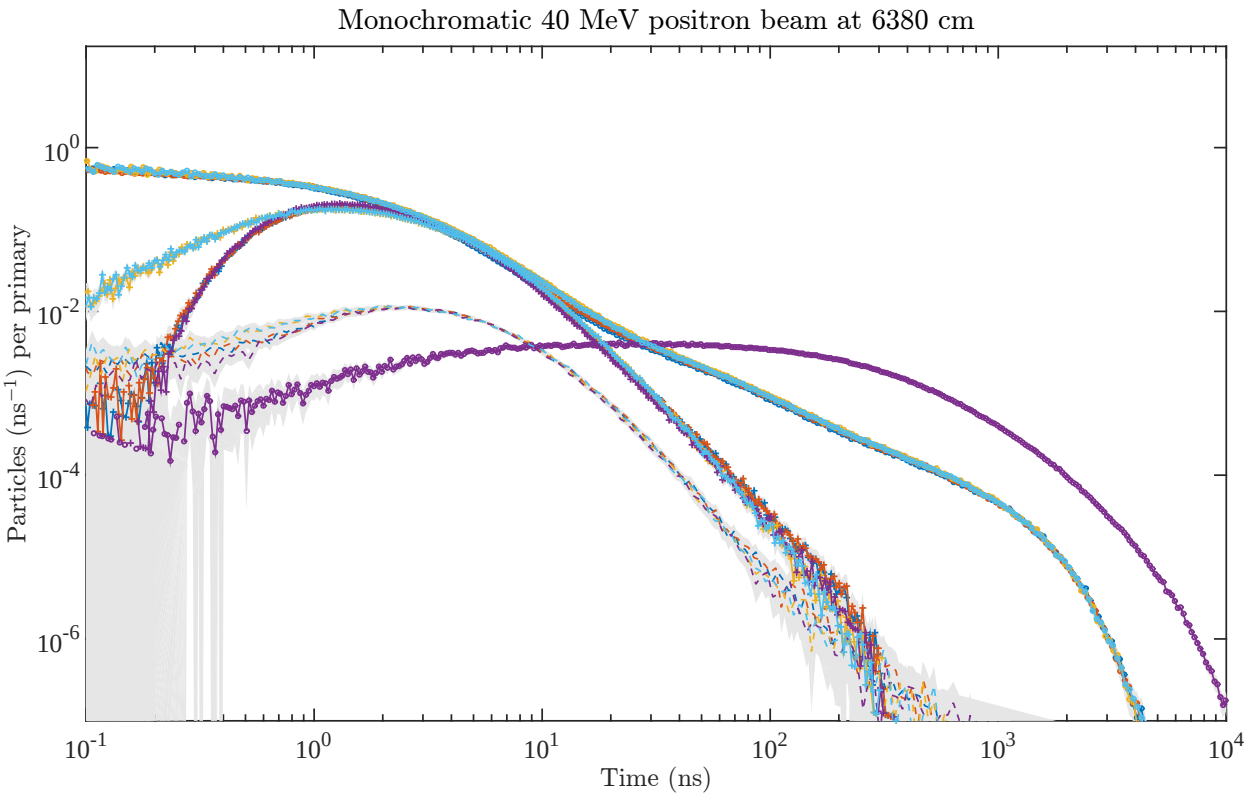

Monochromatic 10 MeV positron beam at 2010 cm
Particles (ns^{-1}) per primary
Time (ns)

3.5 Initial 40 MeV kinetic energy, detector distance at 6380 cm






Monochromatic 40 MeV positron beam at 6380 cm
Particles (cm^{-2}) per primary
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
Radial distance from symmetry (cm)


Monochromatic 40 MeV positron beam at 6380 cm
Particles (ns^{-1}) per primary
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Time (ns)