SmartPhantom: Effect of “Shiny” Black Aluminium

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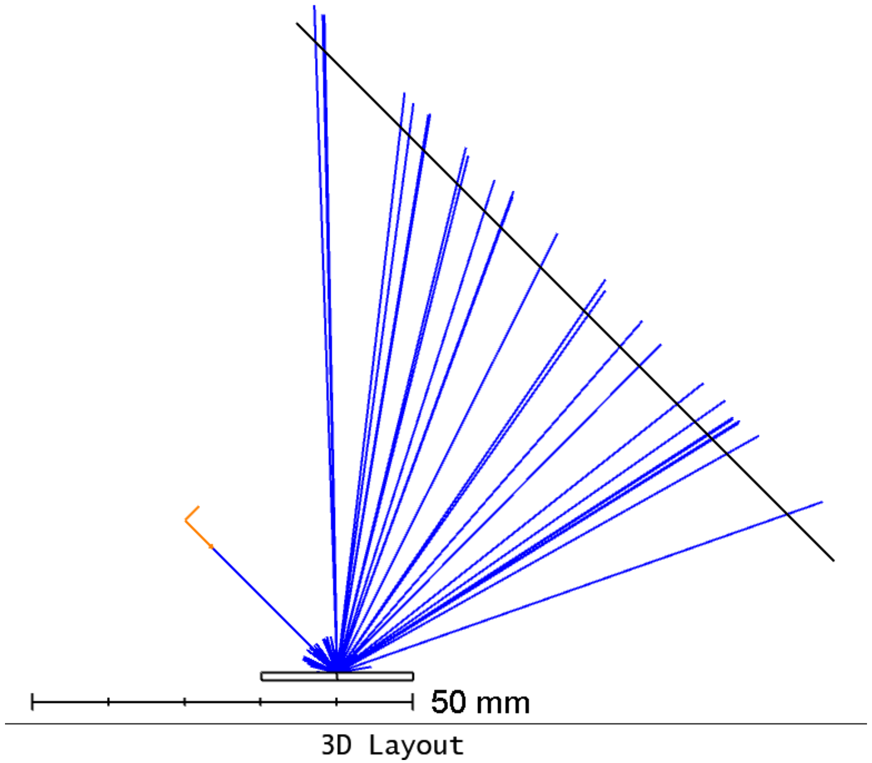
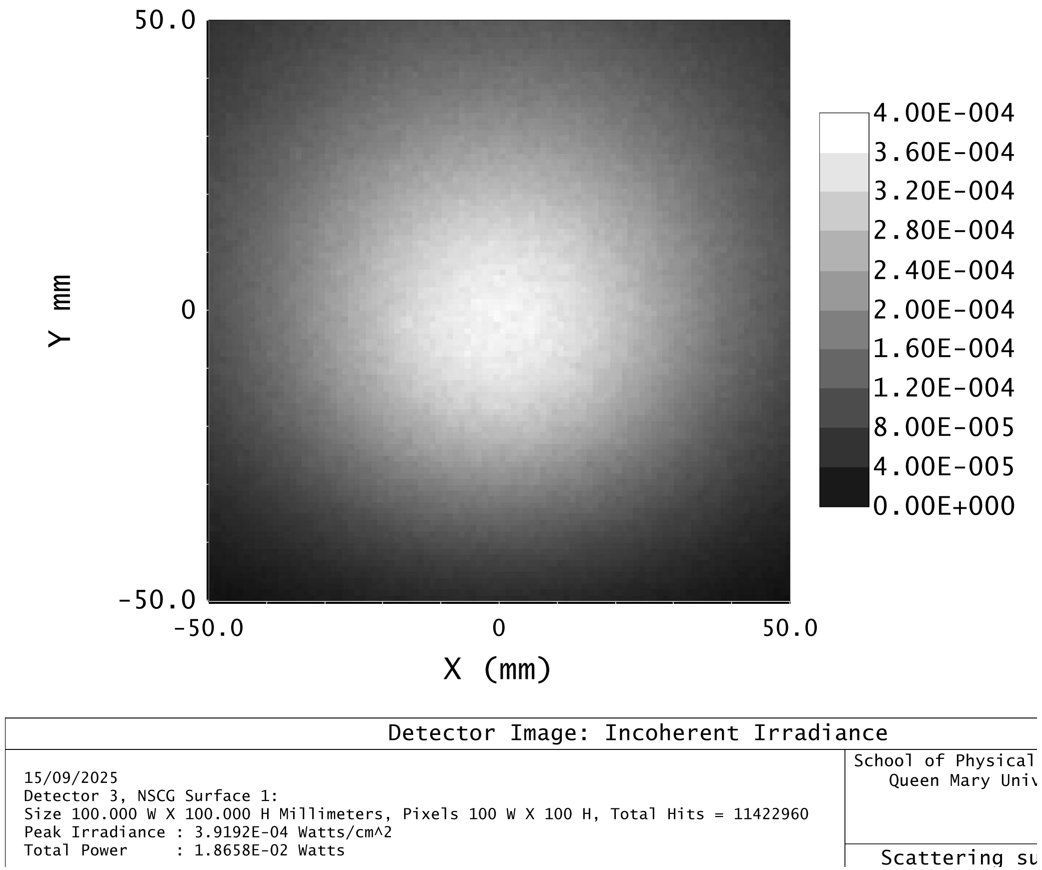
Simulation parameters

1. SmartPhantom is assumed to contain Ultima Gold XR;
2. Non-sequential ray tracing is used;
3. Imaging optics are pairs of achromatic doublet lenses (as at LION);
4. The emitting cylinder is 1.0 mm in diameter divided into 15 longitudinal segments each 0.5 mm long;
5. Simulations use **Ansys ZEMAX OpticStudio Premium 2025R1.01** (PC is an i5 6/12 core @4.6 GHz peak with 32 Gbytes of 3200 MHz DDR4 memory);
6. Data shown for a weighted set of wavelengths from 406 nm to 525 nm.
7. The data are shown in camera coordinates not object coordinates.

Scattering from a Lambertian Surface

Scattering surface is "black aluminium", 95.1 % absorbing. Total power from point source is 1.0 W. All light reflected is via Lambertian scattering



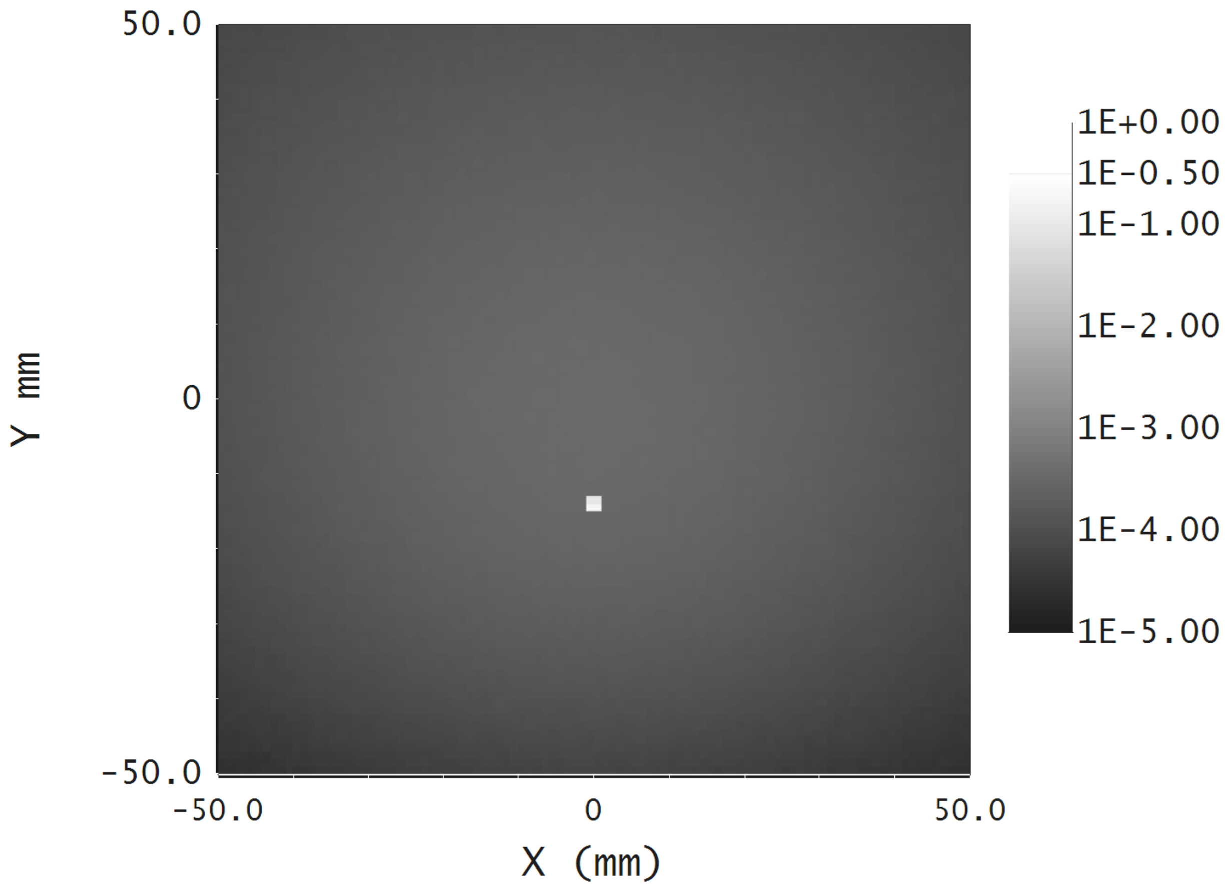


Scattering from a Lambertian Surface

Scattering surface is "black aluminium", Total power from point source is 1.0 W

Here 5% of the light that is **not absorbed** is specular reflected and 95 % of non-absorbed light is Lambertian scattered.

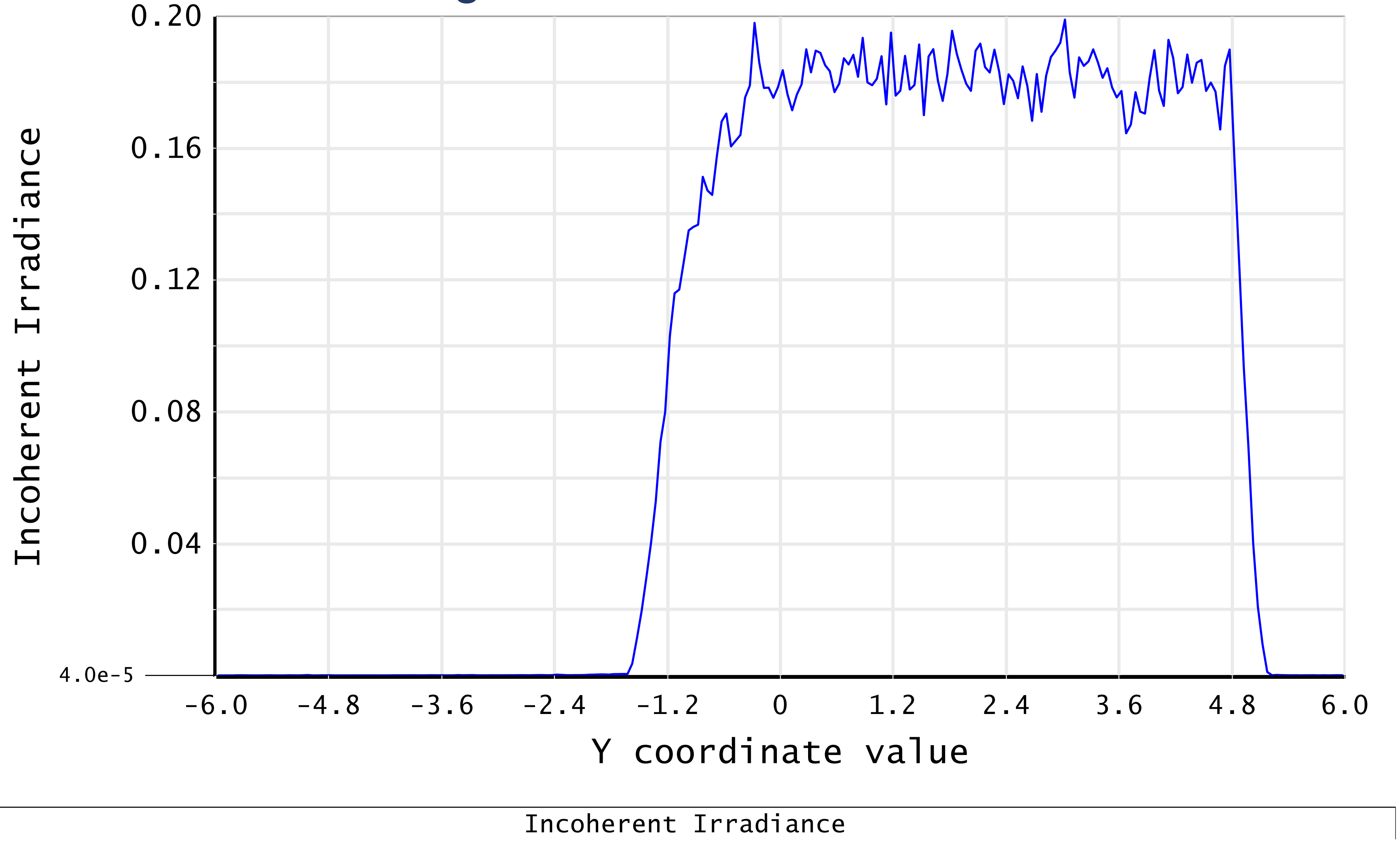
Note the logarithmic irradiance ($W.cm^{-2}$) scale



Detector Image: Incoherent Irradiance

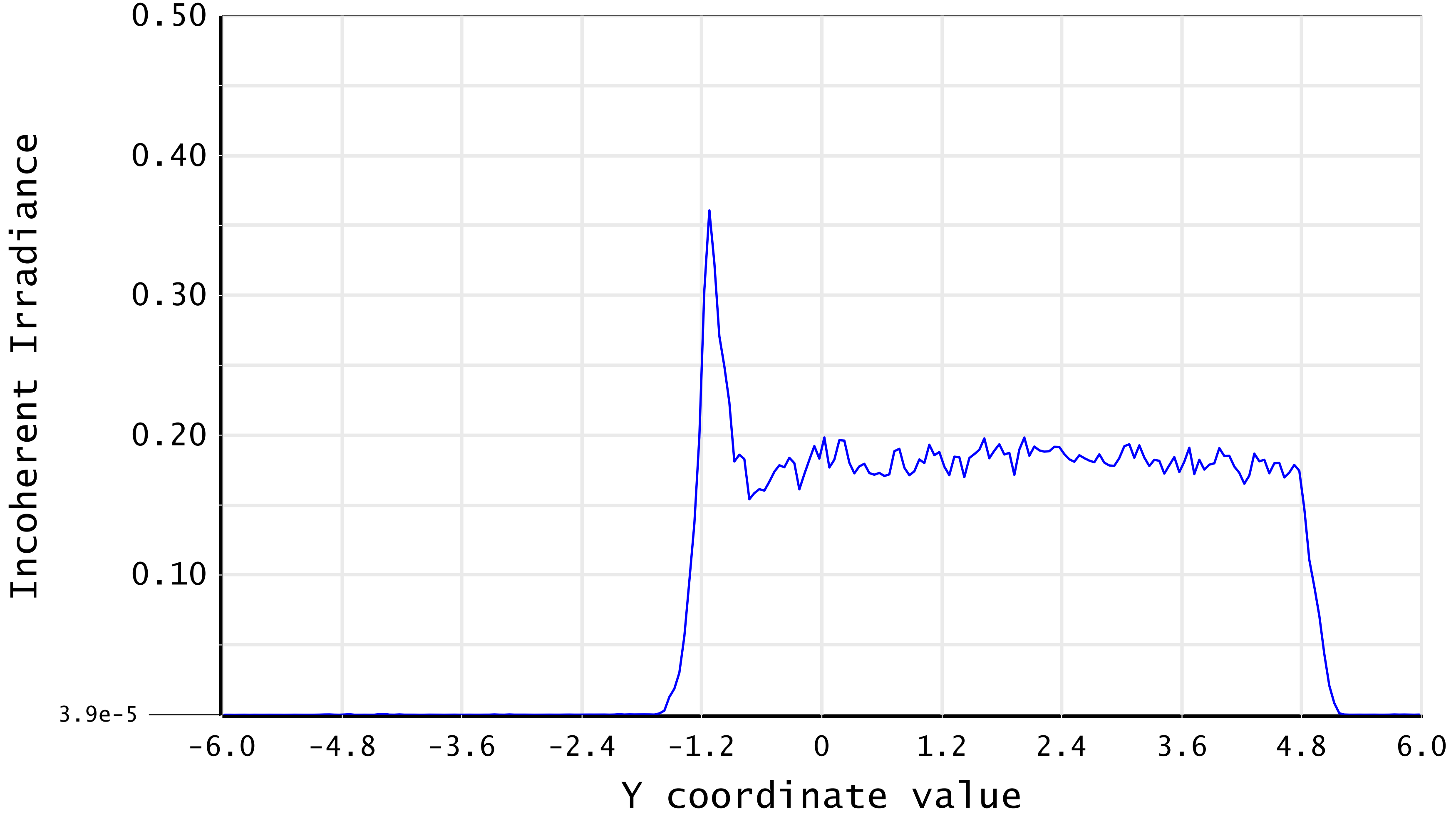
Support Ring – Diffuse Black Aluminium

All ring surfaces “black aluminium”



Support Ring – Inner ring 100% Reflective

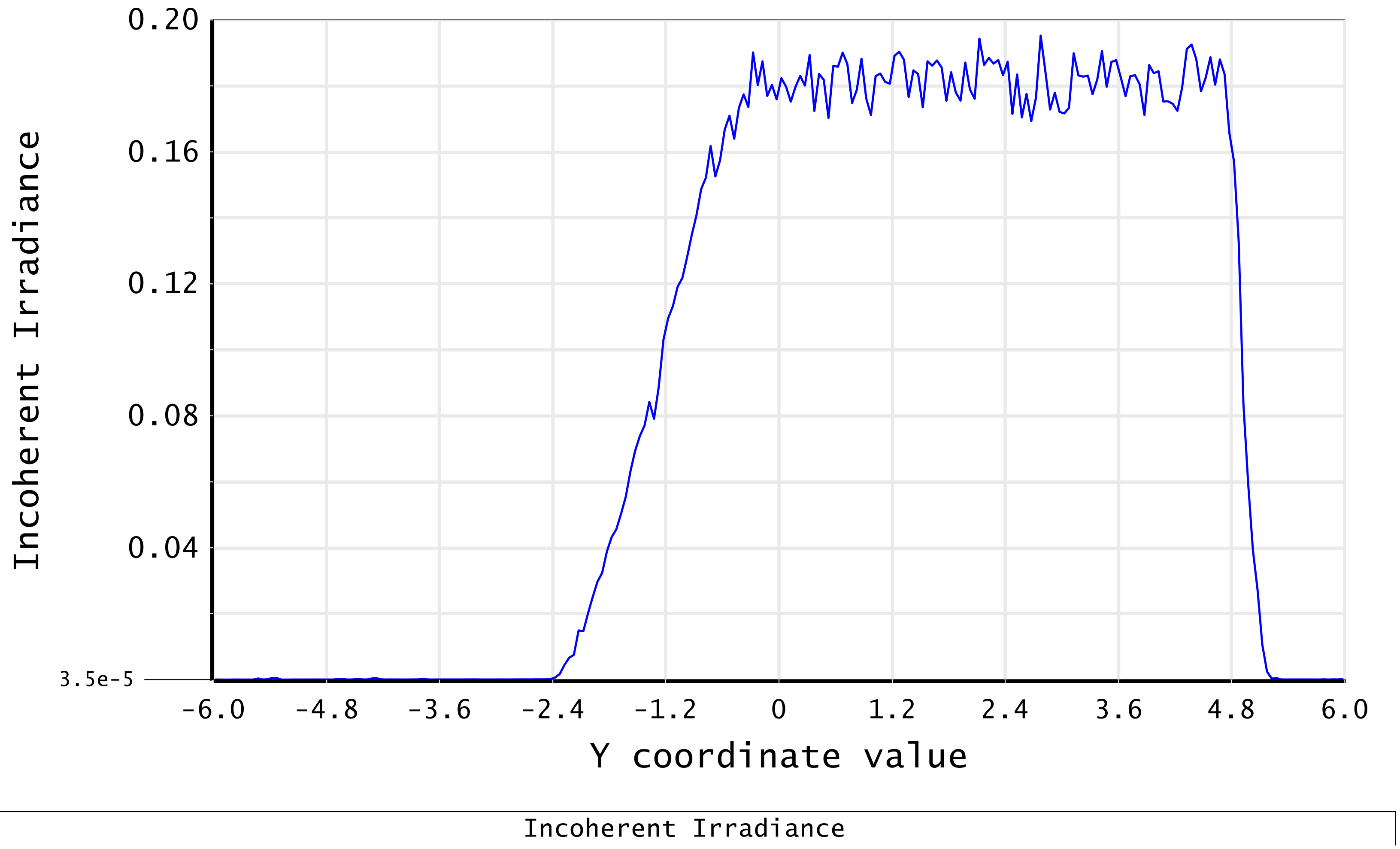
All other surfaces "black aluminium"



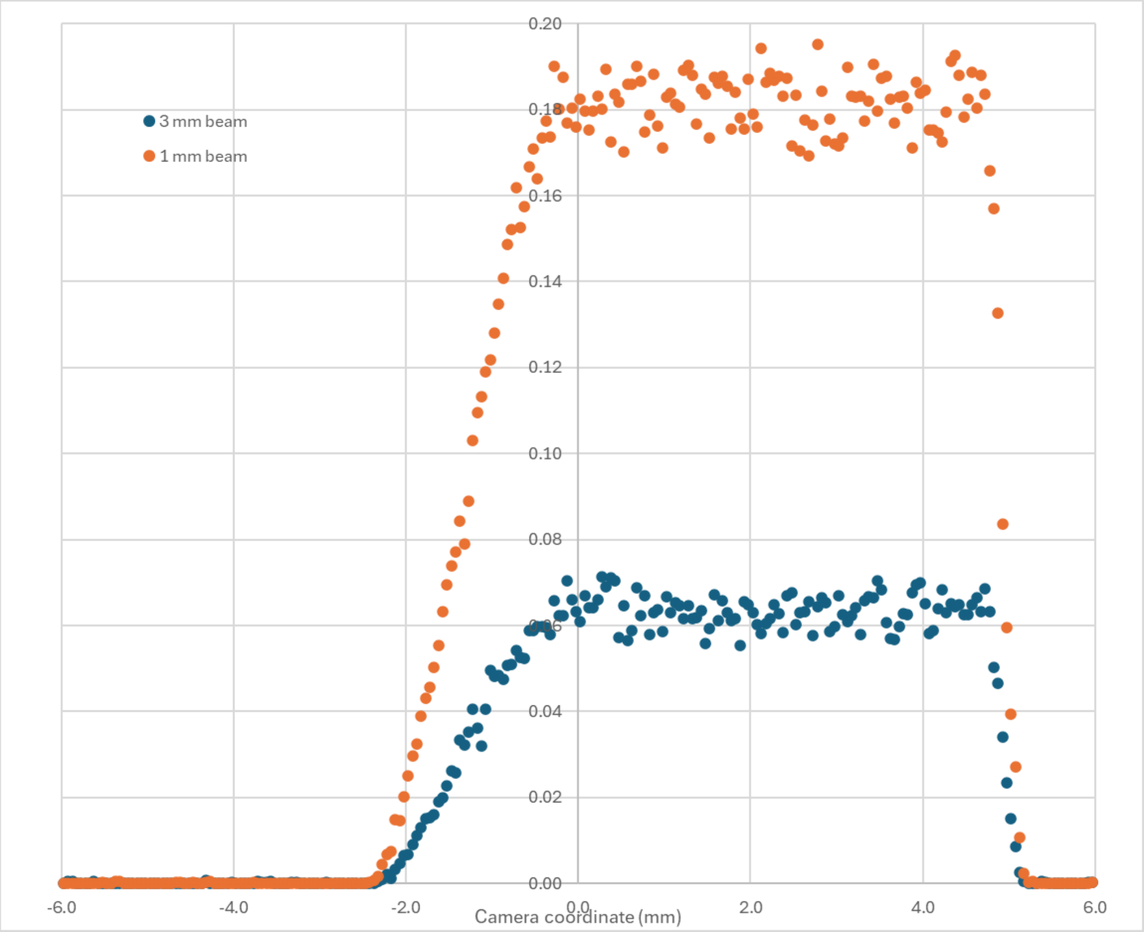
Incoherent Irradiance

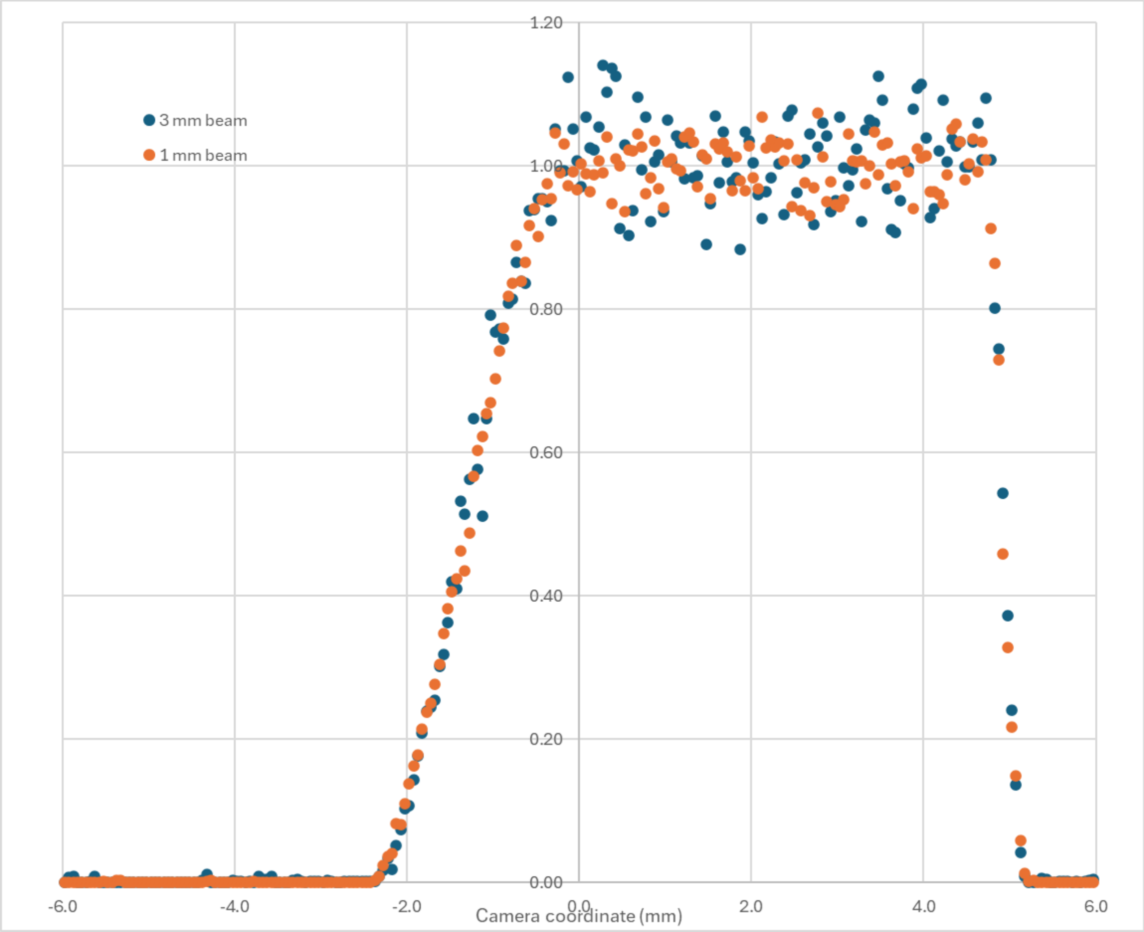
Support Ring – Outer faces 100% Reflective

Inner surface “black aluminium”



Support Ring – Effect of Beam diameter

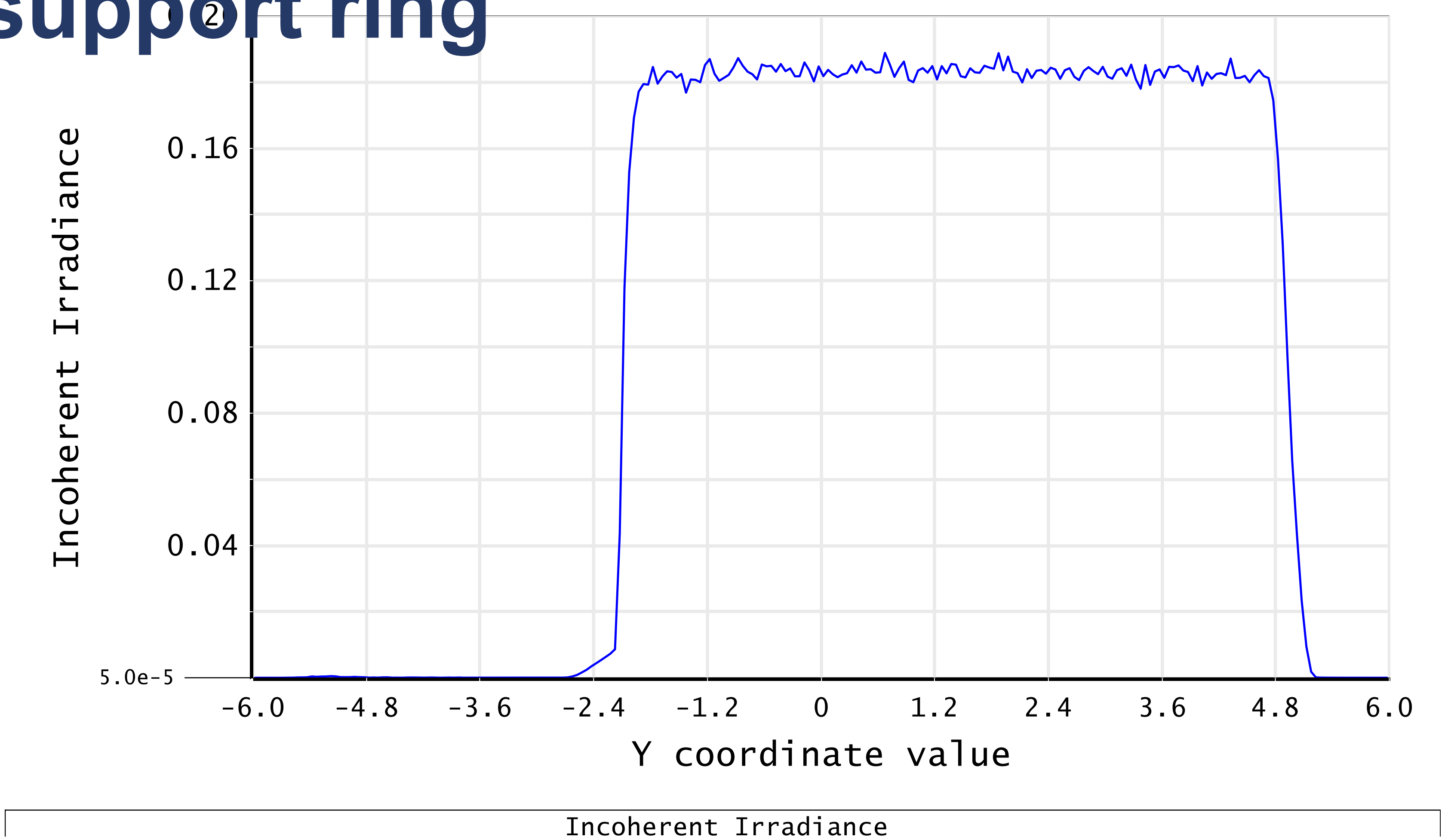




Outer faces of ring are 100% R, inner face of ring is “black aluminium”

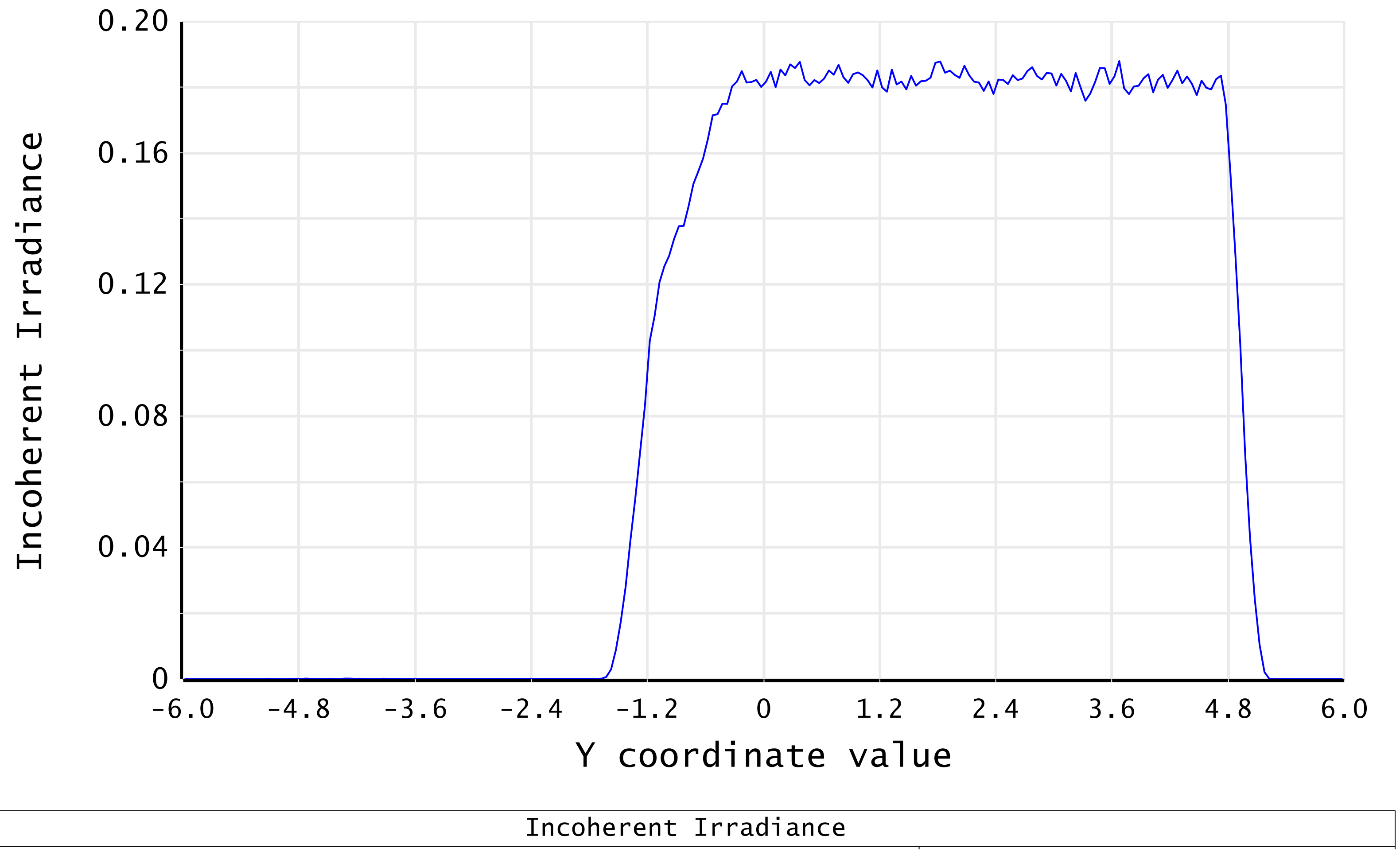
LH plot shows the “raw” data, RH plot shows data normalized to the mean in [1,3]

All Black Surfaces (not Kapton®) 100% Absorbing
No support ring



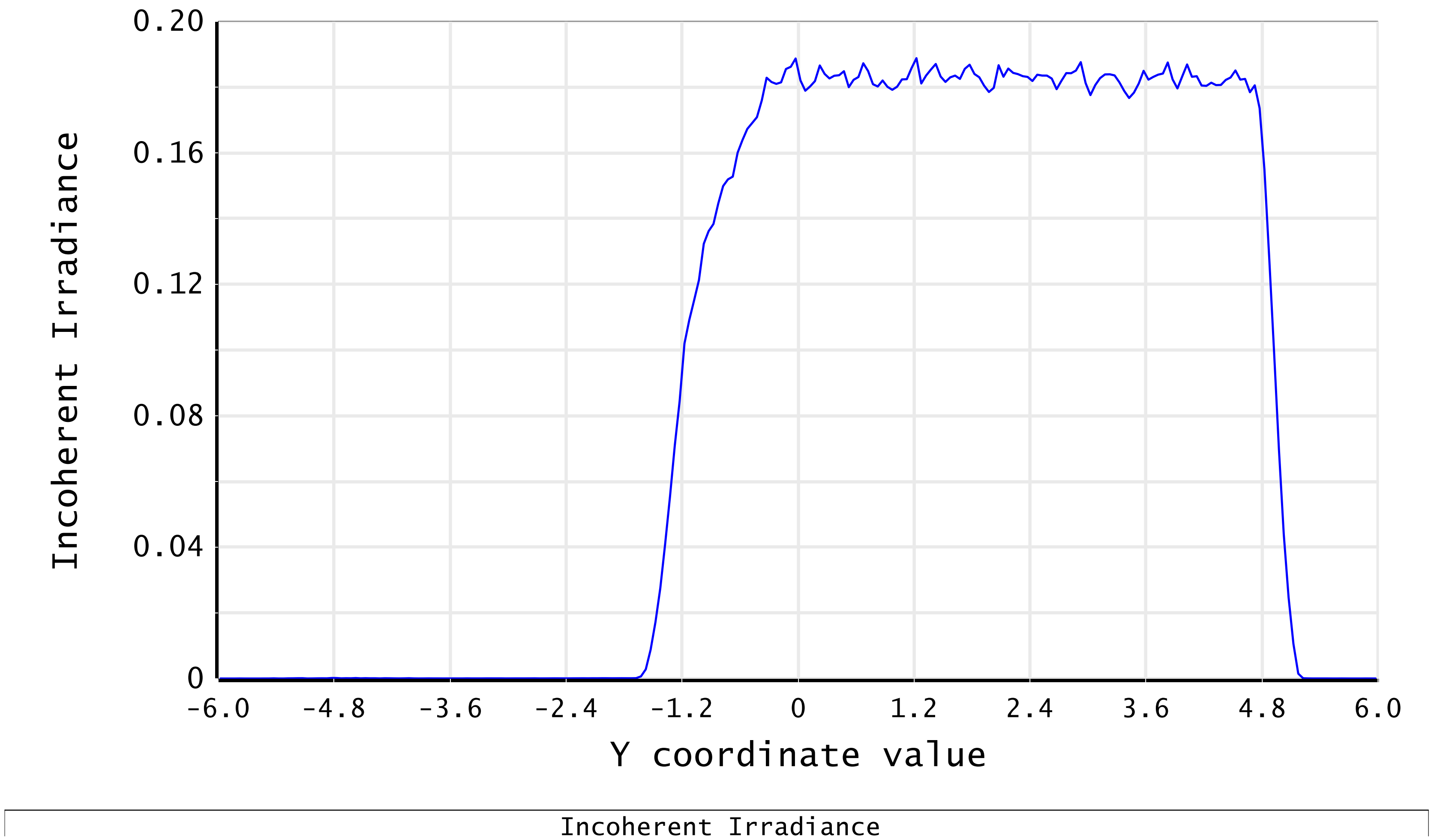
15×10^8 primary rays traced, ray splitting ON, 1.0 mm diameter beam

All Black Surfaces (not Kapton®) 100% Absorbing



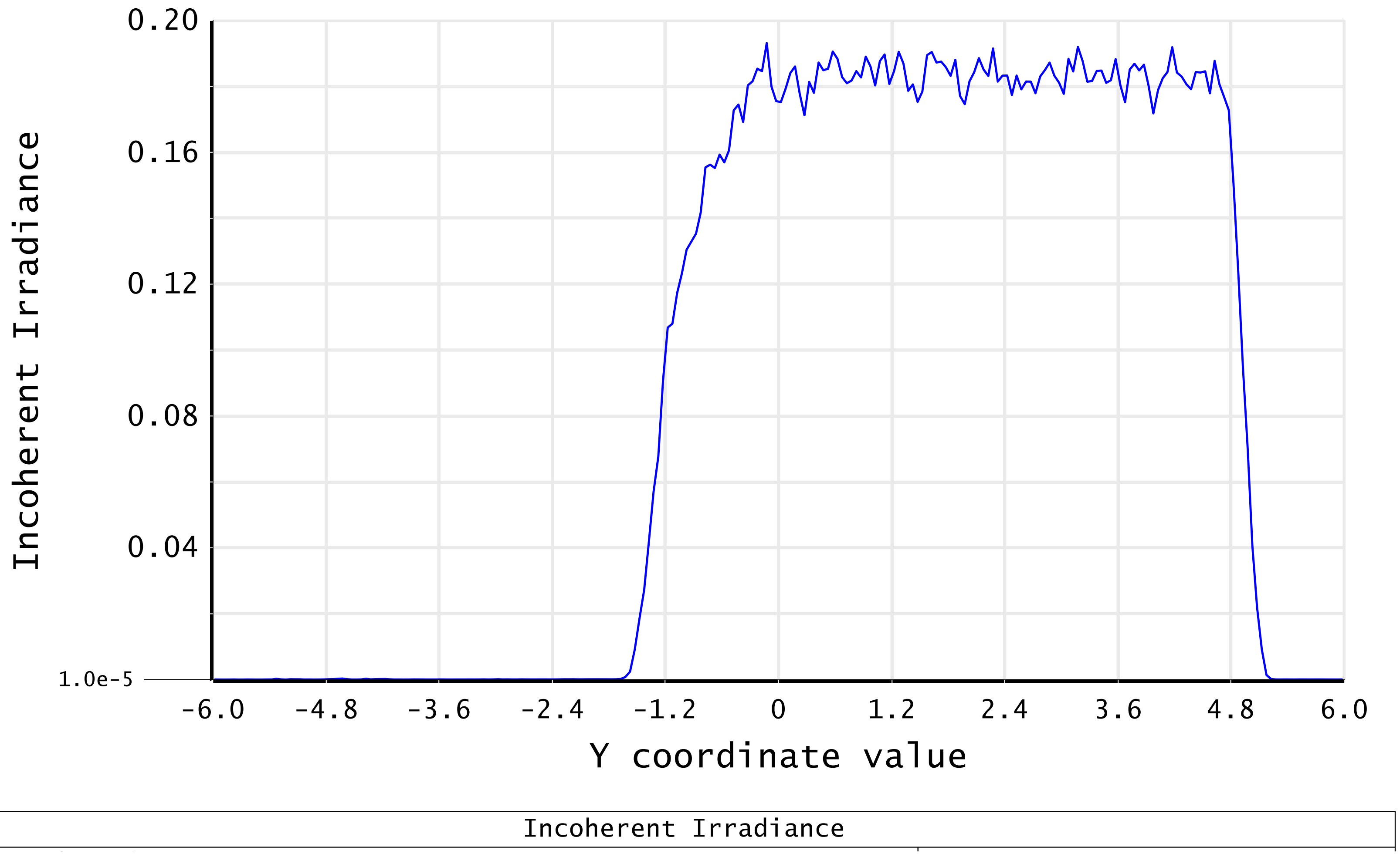
$15{\times}10^8$ primary rays traced, ray splitting ON, 1.0 mm diameter beam, **support ring included** (occlusion effect).

Most Surfaces (not Kapton®) 100% Absorbing



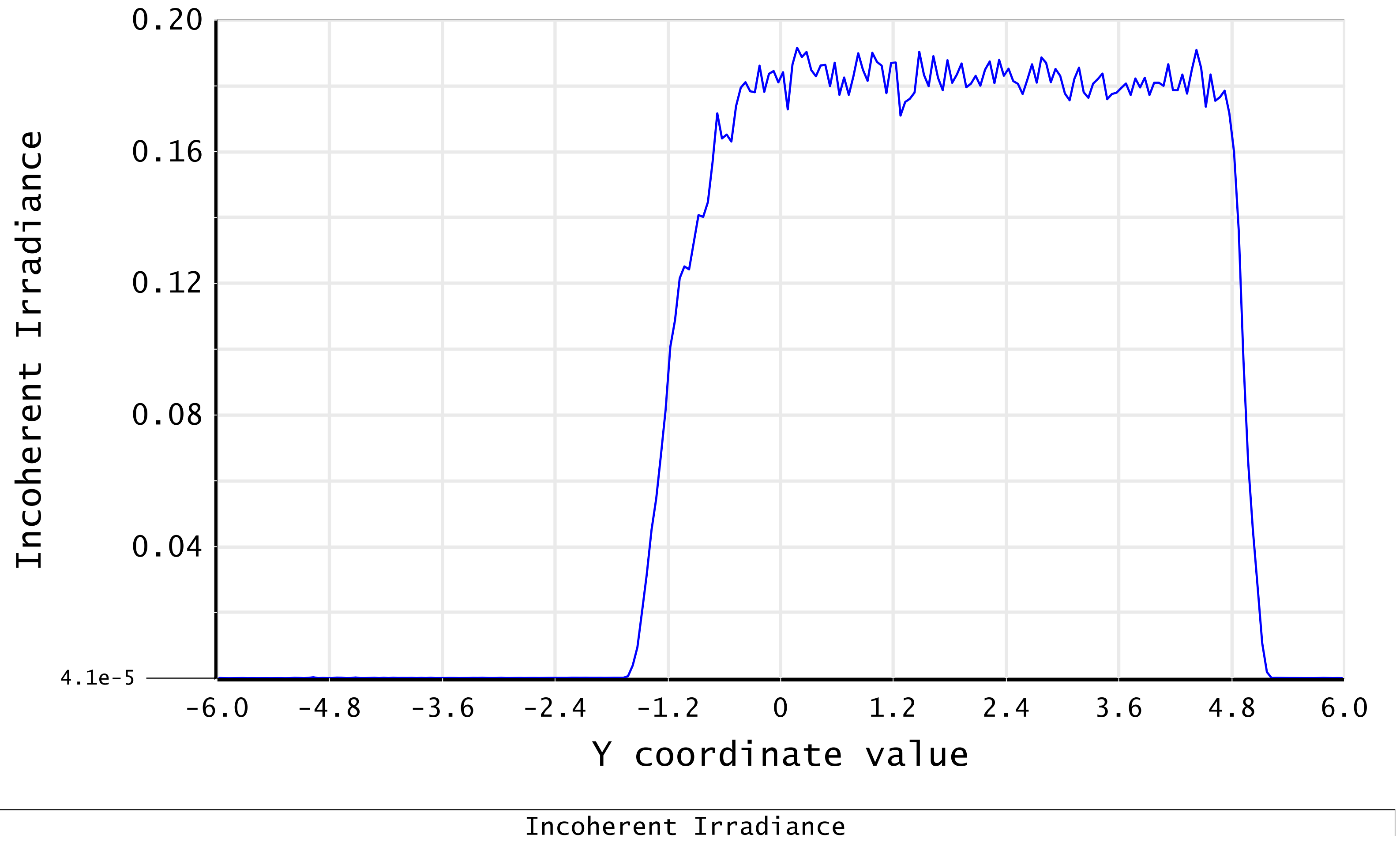
15×10^8 primary rays traced, only tube before BK7 window scatters

Some Surfaces (not Kapton®) 100% Absorbing



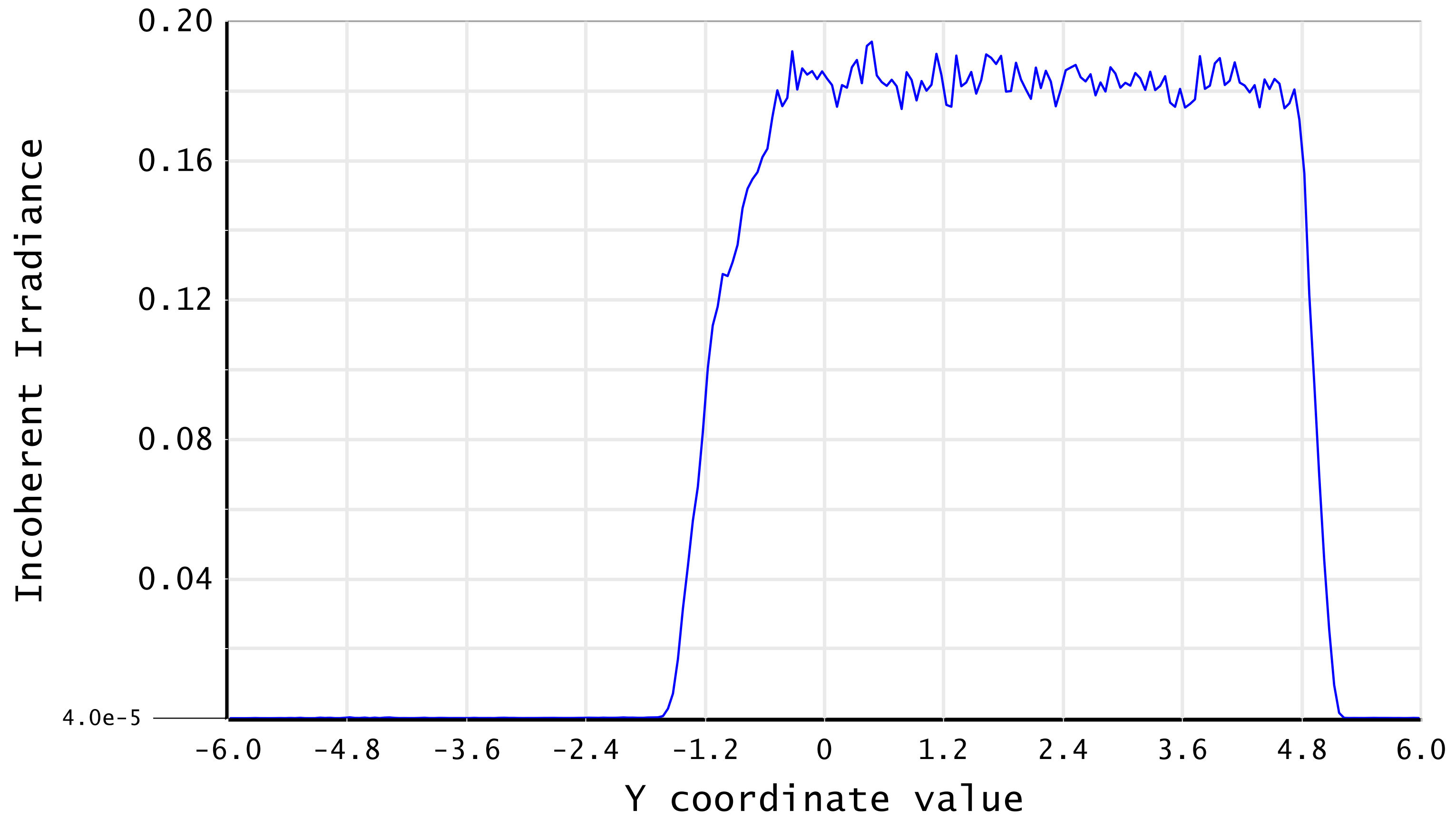
450×10^6 primary rays traced; tube before BK7 window and main cuboid scatter

Some Surfaces (not Kapton®) 100% Absorbing



450×10^6 primary rays traced; tube before BK7 window and main cuboid scatter plus inner ring of fibre-plane support

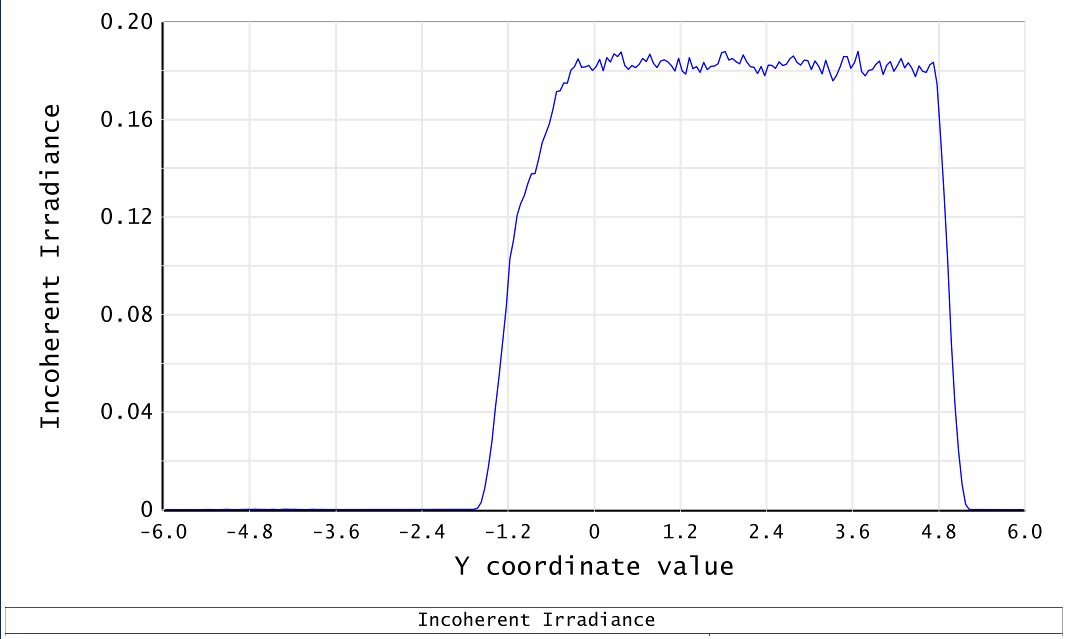
All Surfaces Absorb & Scatter

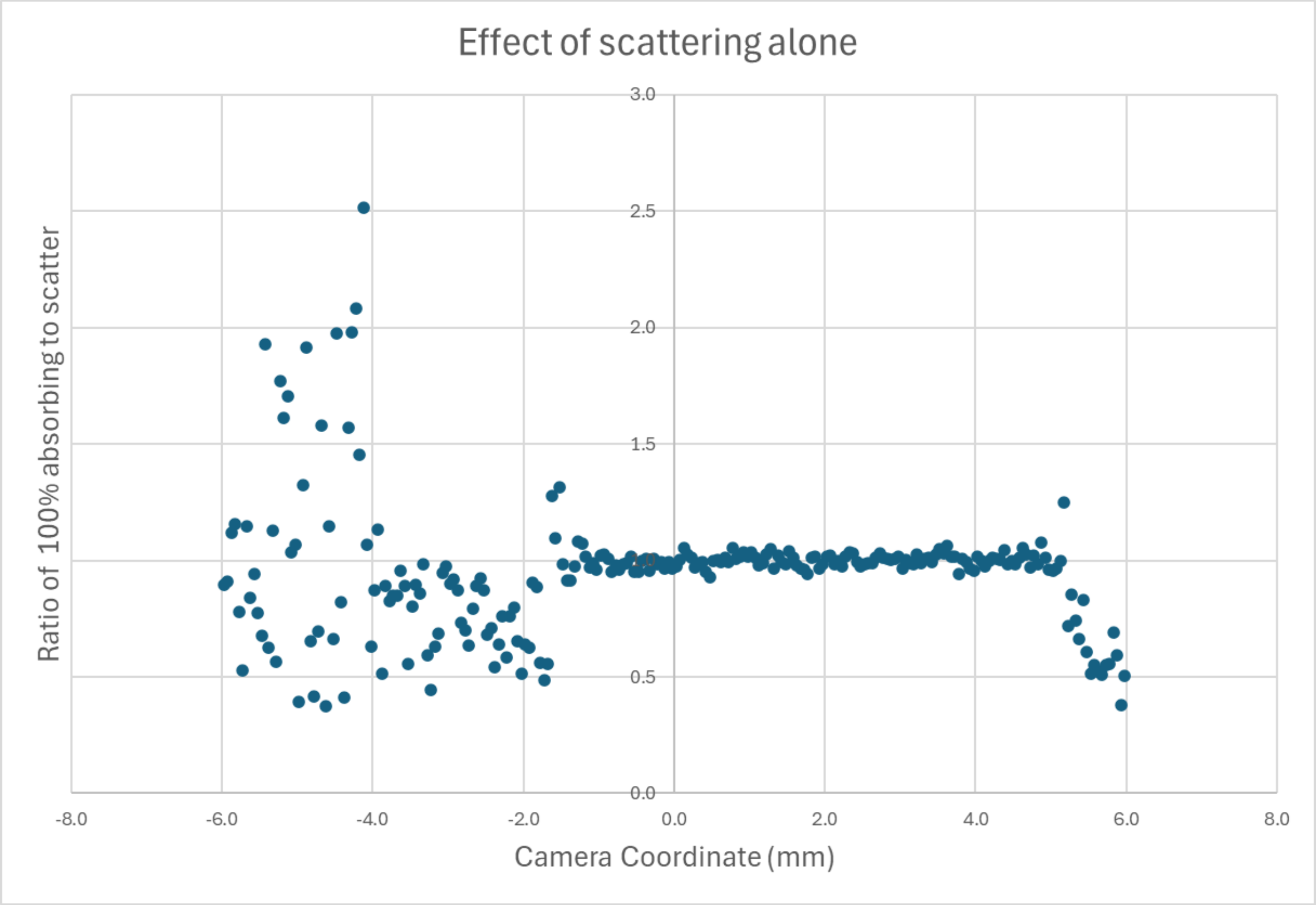


Incoherent Irradiance

450×10^{6} primary rays traced; tube before BK7 window and main cuboid scatter plus all of the fibre-plane support

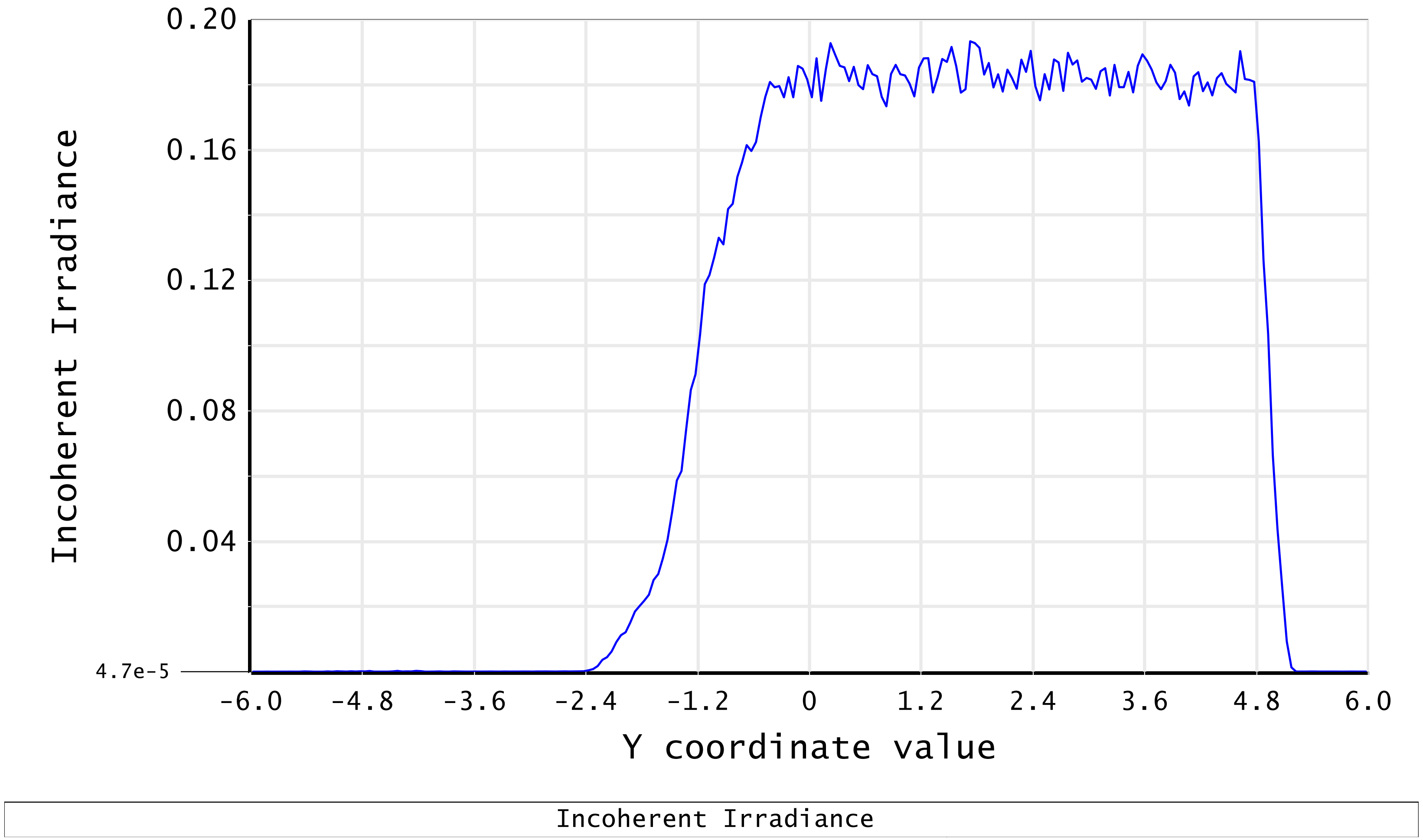
Ratio compared to all absorbing (except Kapton®)





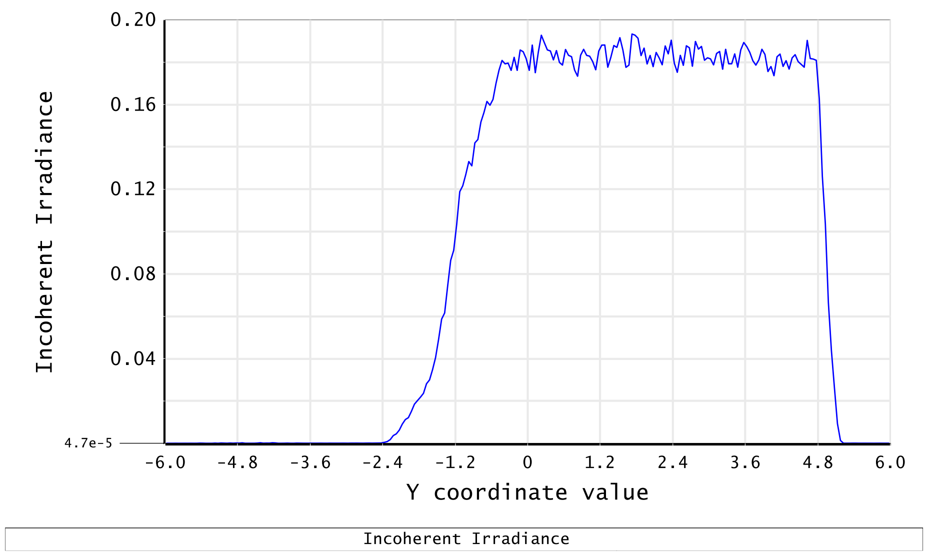
Tube before BK7 window, main cuboid and all of fibre-plane support scatter.

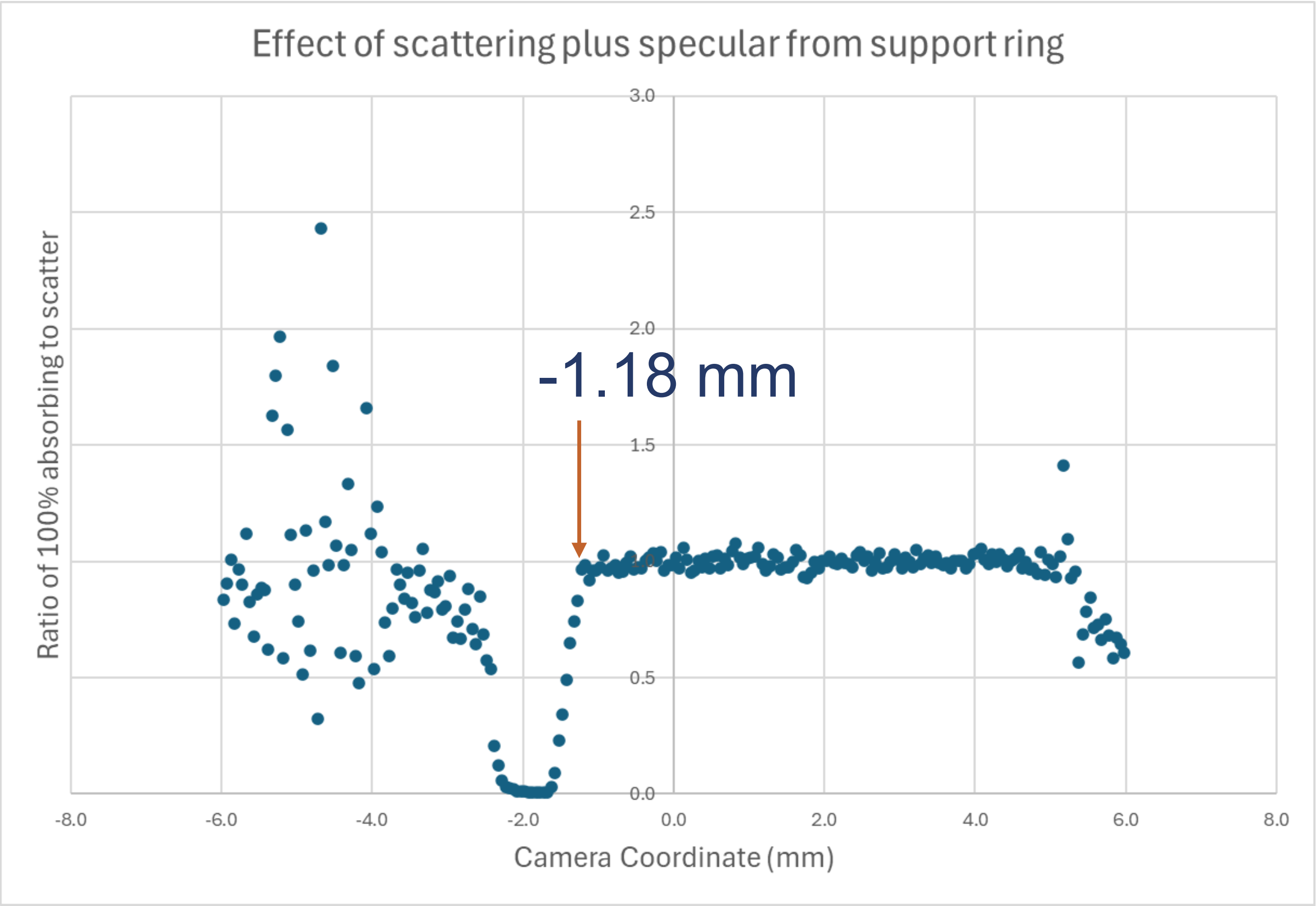
All Surfaces Absorb & Scatter, Ring is Shiny



450×10^6 primary rays traced; tube before BK7 window and main cuboid scatter. The fibre-plane support is 50/50 scatter and specular (and 95% absorbing).

Ratio compared to all absorbing (except Kapton®)

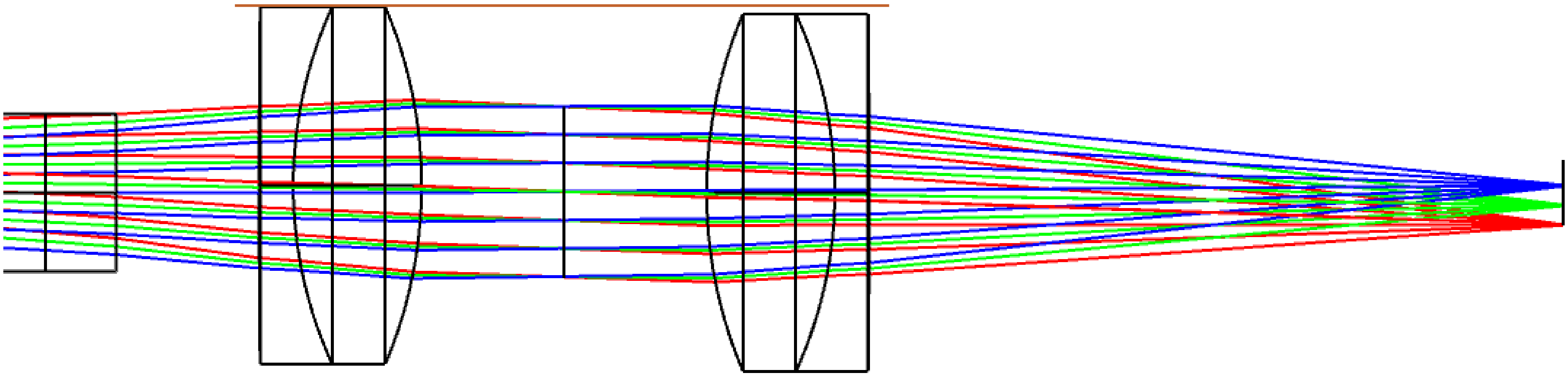




Tube before BK7 window, main cuboid and all of fibre-plane support scatter.
Fibre-plane support is 50/50 scatter & specular (and 95% absorbing).

Effect of possible doublet lens lateral shift

One, or both, of the doublet lenses could be laterally translated within the lens tube by upto ~ 0.5 mm from the tube axis. What effect does this have?



First doublet lens laterally translated by 0.50 mm from the tube axis. This shifts the 0.0 mm field point (blue rays) by 0.50 mm in the other direction.

Recommendation

Ignore all optical data from LION that starts before (-1.18 +0.5) mm from the optical axis.

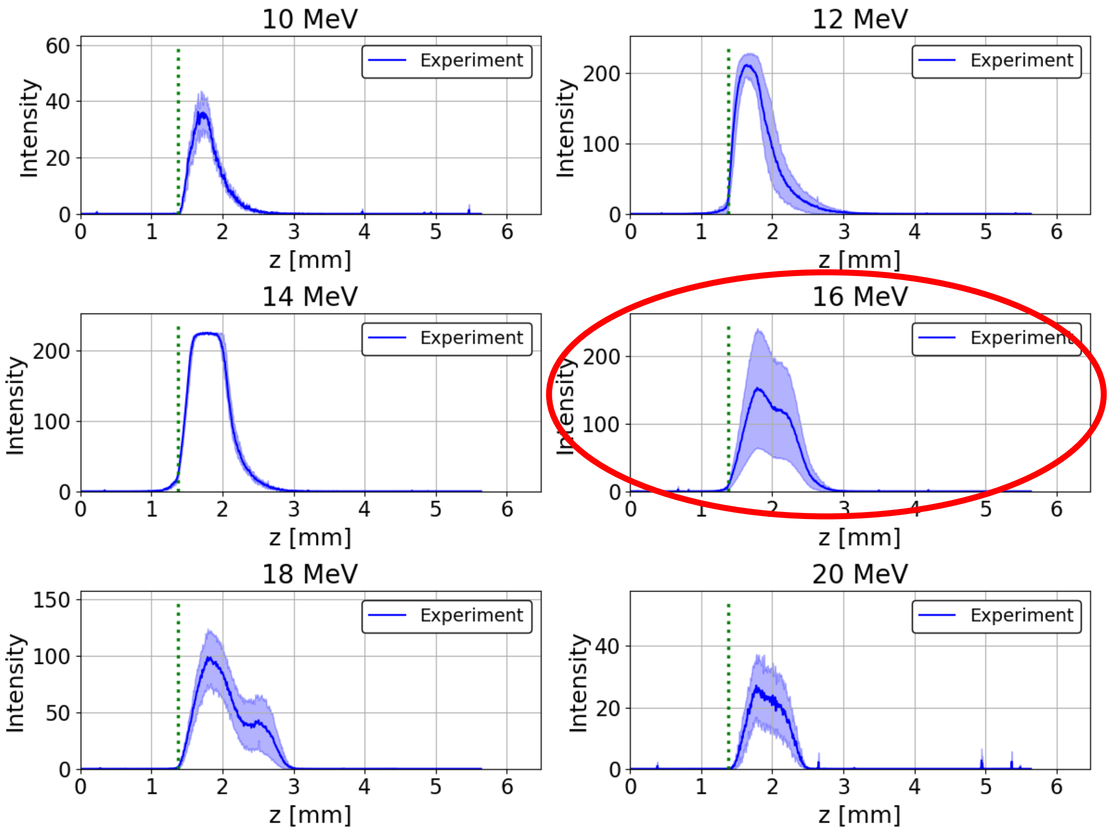
This should be an appropriate starting point considering the graph on slide 20 plus worst-case misalignment of optics.

Integrate all light from -0.68 mm onwards and encompassing all the beam width (not just the 60 pixel wide strip used so far in our analysis) above some threshold.

Compare with total energy from ion-acoustic signal at 16 MeV.

Recommendation

Assuming (very hard to verify) that the factor of 4 variation in optical signal at 16 MeV is primarily due to variation in the *number* of protons and not changes in beam profile or beam energy then compare each individual event optical energy with “Hobson” cut with total acoustic energy.



Plot from Maria’s talk at the LhARA Collaboration Meeting at UCL on 7 April 2025