Sparse Fibre Plane – First thoughts

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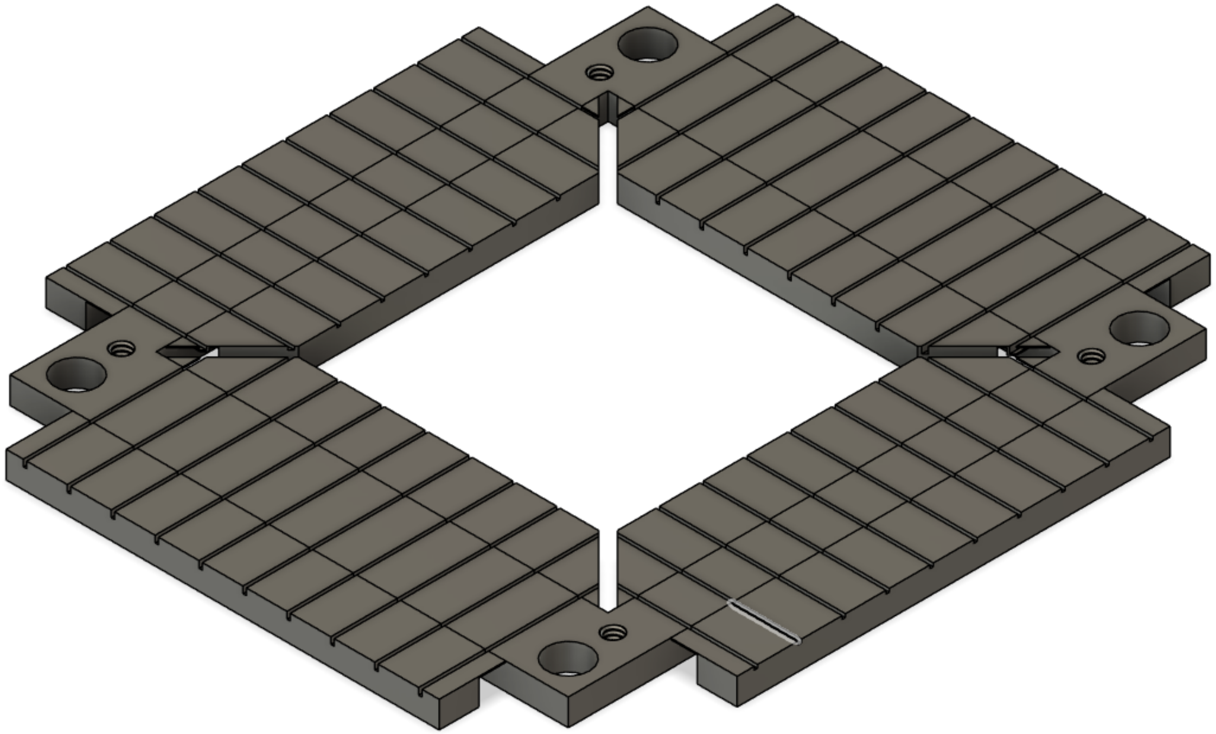
Simulation parameters

1. Starting to look at Ken's new sparse fibre plane for PoPLaR beam monitoring;
2. Non-sequential ray tracing is used;
3. 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);
4. Data shown for a wavelength of 491 nm (emission peak of scintillator);
5. Toy fibre at the moment to ensure I have the correct simulation parameters to minimise ray-trace errors.

3D Render of Sparse Fibre Plane Support

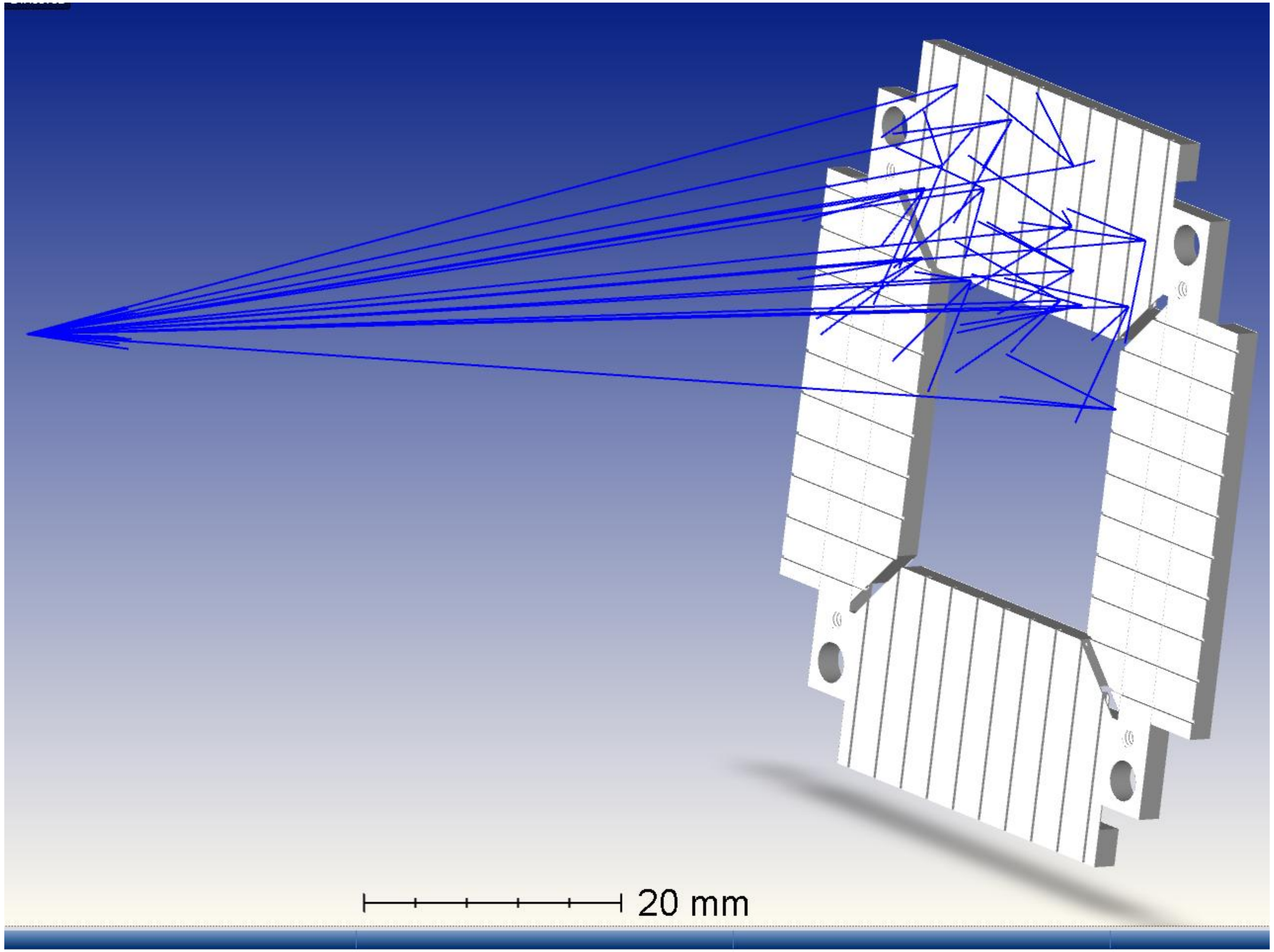


This is 48 × 42 mm in size and takes 250 μm diameter BCF-20 fibres. I now have the detailed drawings and a STEP file which has been imported into ZEMAX.

3D Render of Sparse Fibre Plane Support

48 × 42 mm in size and takes 250 μm diameter BCF-20 fibres.

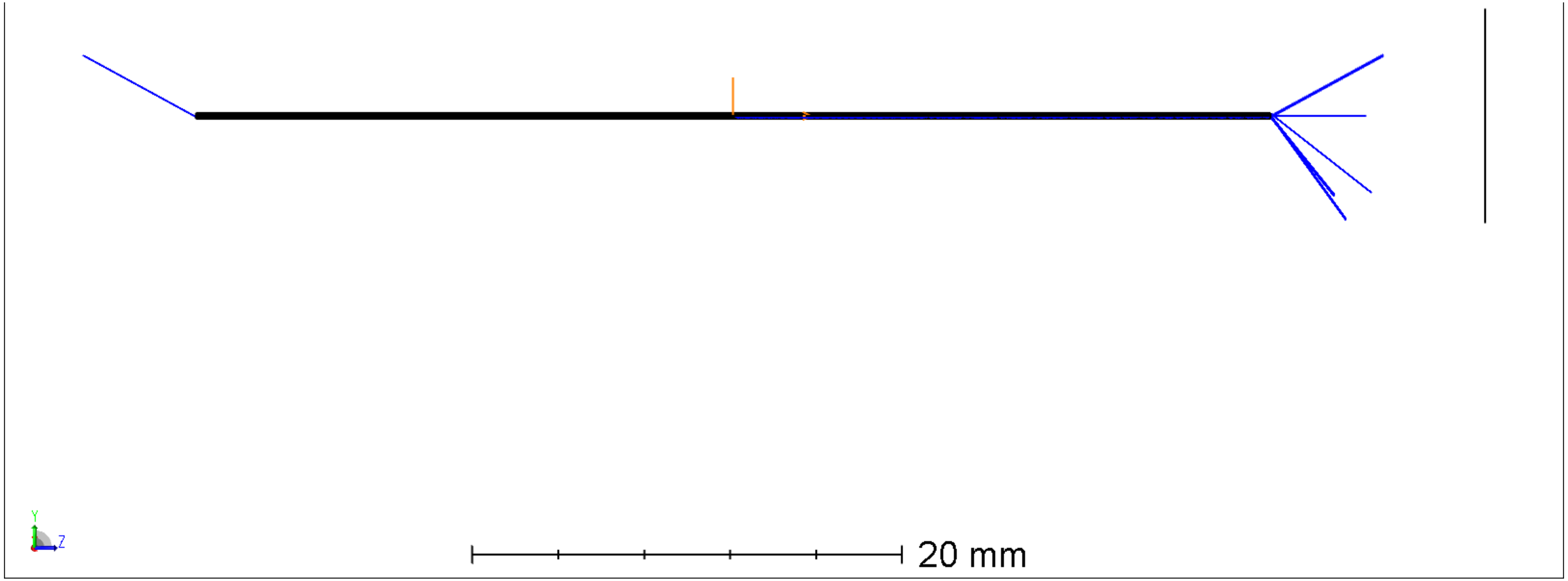
This is coated with “Black Aluminium” with Lambertian scattering but no specular reflections.



Toy Fibre

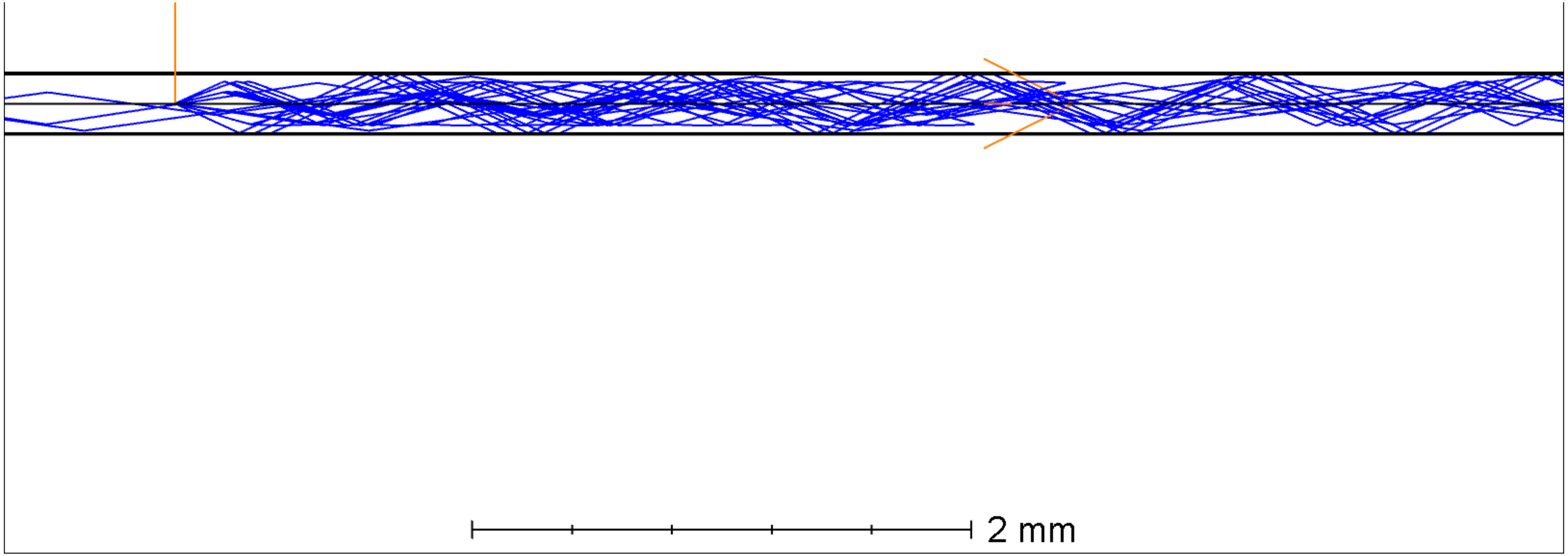
Simulated at Polystyrene (Core) and PMMA (cladding) as per BCF20. NA = 0.58

50 mm long fibre

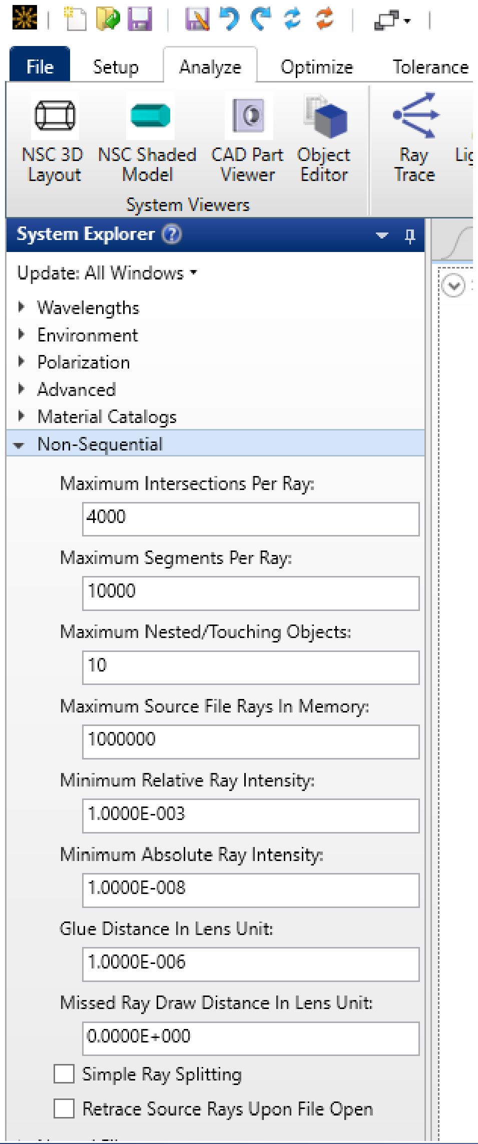


Toy Fibre

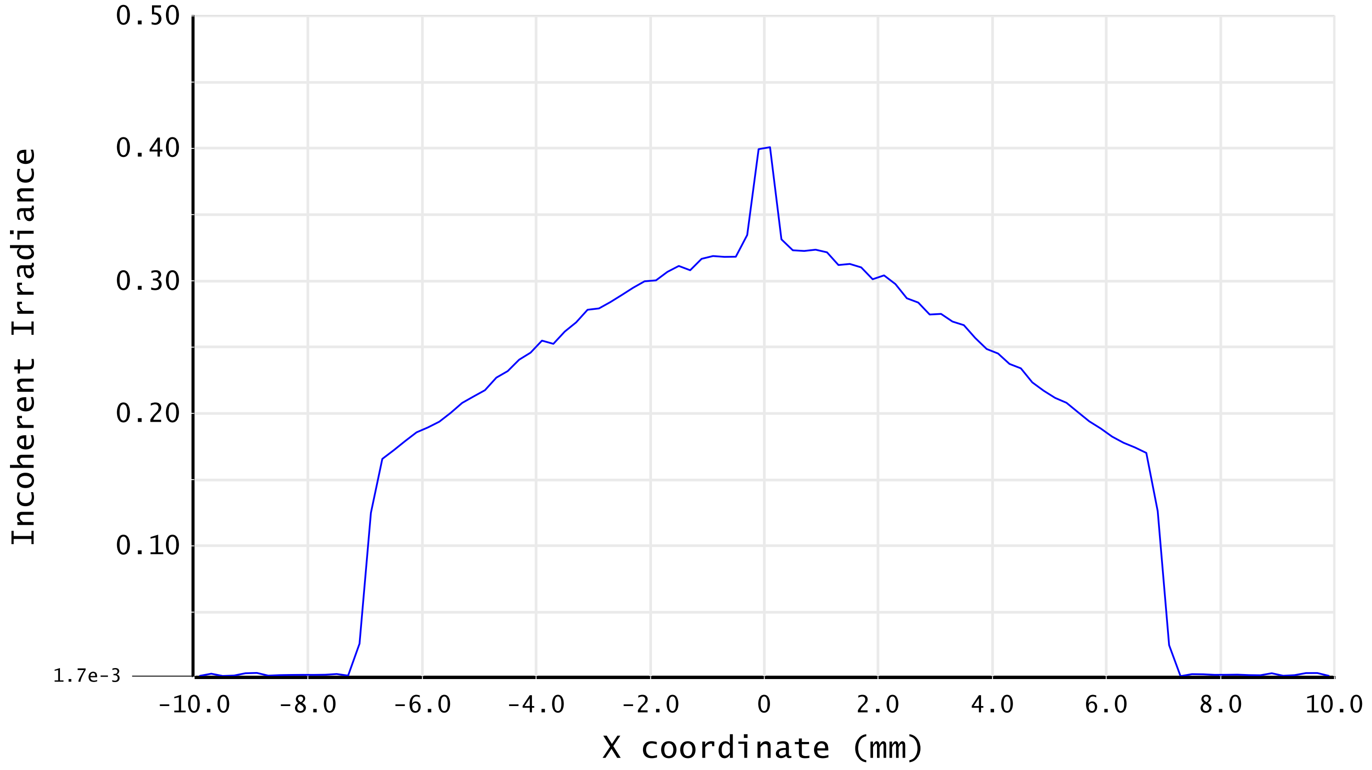
Here you can see core and cladding modes from a point source with a 35 degree cone angle emitting to the right. Remember we get Fresnel reflection at the ends of the fibre.



NS parameter settings used currently



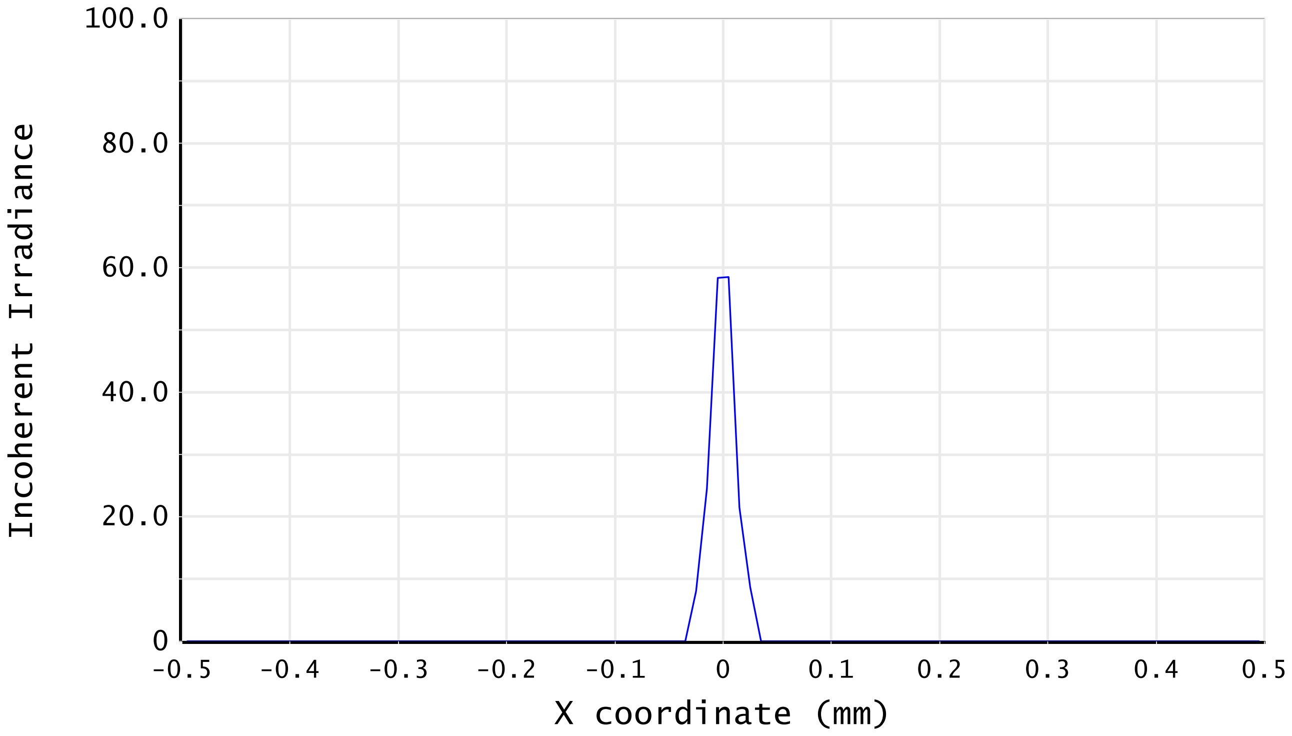
Light Distribution 10 mm after Fibre (no lens)



Incoherent Irradiance	
Fibre Test for PoPLaR 12/12/2025 Detector 4, NSCG Surface 1: Row Center, Y = 0.0000E+00 Size 20.000 W X 20.000 H Millimeters, Pixels 100 W X 100 H, Total Hits = 465598 Peak Irradiance : 4.0100E-01 Watts/cm^2 Total Power : 3.5433E-01 Watts	School of Physical & Chemical Sciences Queen Mary University of London Fibre_TestBCF20.zmx Configuration 1 of 1

Nominal source of power 1W, 1 million primary rays traced.

Light Distribution Imaged to Camera



Incoherent Irradiance	
Fibre Test for PoPLaR 12/12/2025 Detector 5, NSCG Surface 1: Row Center, Y = 0.0000E+00 Size 1.000 W X 1.000 H Millimeters, Pixels 100 W X 100 H, Total Hits = 6324 Peak Irradiance : 5.8817E+01 Watts/cm^2 Total Power : 6.2057E-04 Watts	School of Physical & Chemical Sciences Queen Mary University of London Fibre_TestBCF20.zmx Configuration 1 of 1

F = 25 mm, 6 mm aperture paraxial lens located at 150 mm from fibre end. Paraxial image plane shown

Nominal source of power 1W, 1 million primary rays traced.

What next?

Minimise energy lost to ray-trace “errors”;

Include the frame as CAD object with some coating derived from measurements on the actual frame;

Understand space constraints at the vacuum tank used in the PoPLaR facility at SCAPA;

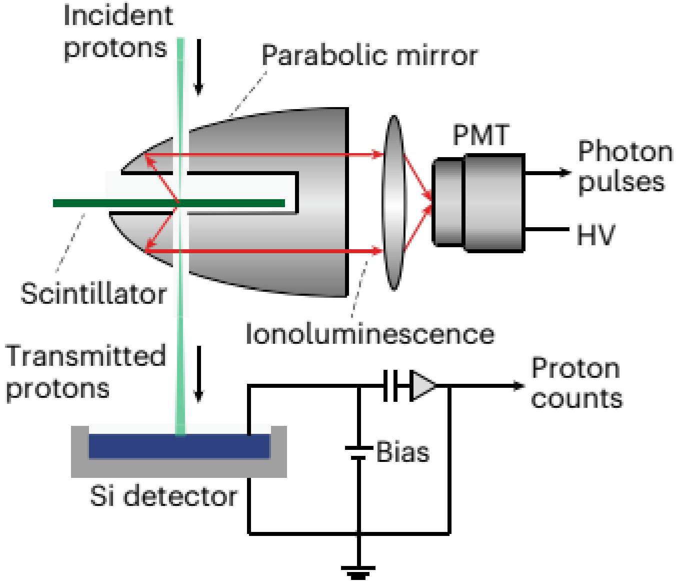
Estimate the typical light produced in a sparse fibre per laser pulse;

Check with sequential ray trace whether new QMUL LhARA cameras and lenses can be sensibly used to image the fibres;

Consider taking the light from the scintillating fibre via a secondary clear fibre (via small air gap) to the camera – could result in much better light collection.

Other approaches?

Detecting/imaging using parabolic or elliptical electroformed optics



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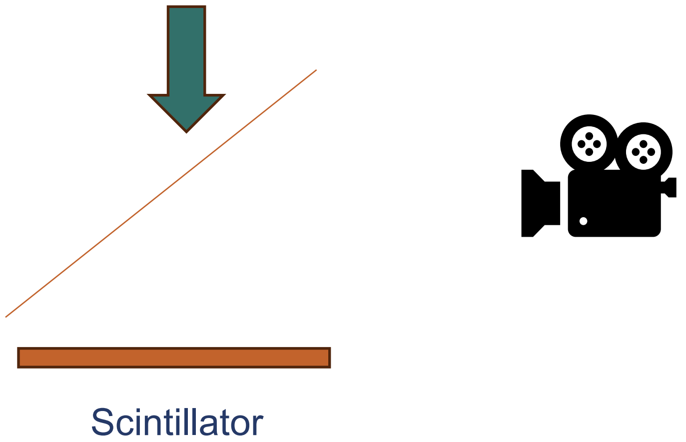
Detecting/imaging using pellicle beamsplitter (hydrocarbon typically 2 μm thick)



Use the area just outside the cell plate which is highly correlated in dose (see Calvin). Readout annular scintillator with WLS fibre and PMT to ≥ 10-bit scope