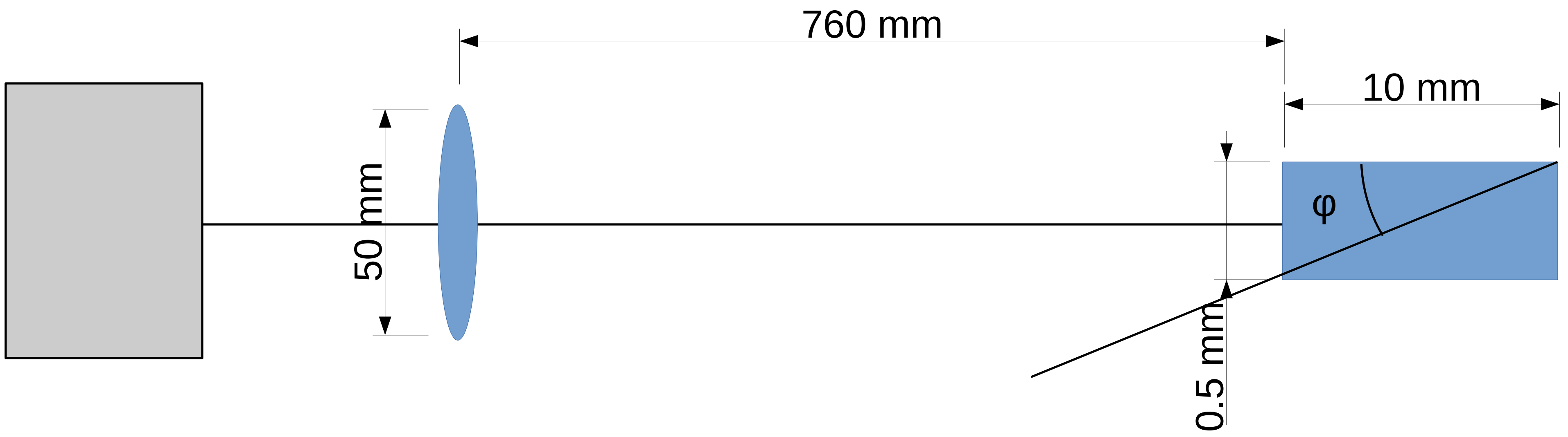
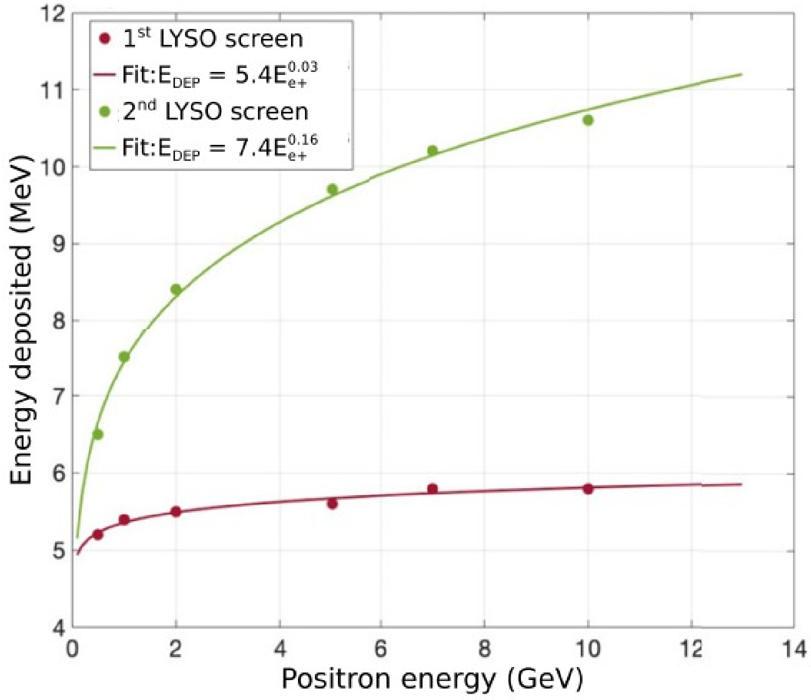


- Exit angle from the LYSO crystal: arctan(0.5 / 10) * 180 / pi = 2.86°
- Acceptance angle of the lens: arctan(50 / 760) * 180 / pi = 3.76°

➤ assumption: each scintillating atom emits uniformly in 4pi: for most of the crystal the primary ray acceptance is determined by the lens

	LYSO(Ce)	Unit
Density	7.25	g/cm^3
Wavelength of Emission Peak	420	nm
Light Output	30,000	ph/MeV
Decay Constant	40	ns



4 mm thickness
for each screen

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Figure 14. Energy deposited at each LYSO scintillating screen per incoming single particle. As the incoming particle travels through the first crystal screen, secondary particles with lower energy are created increasing the energy deposited at the second screen in comparison with the first LYSO. The typical uncertainty on the data points is on the order of 3–5%.

Light collection efficiency:

- Assume: 10 MeV in 0.5 mm x 0.5 mm crystal over 10mm (**verify with Geant4**)
- Assume that all photons are emitted uniformly into 4pi; we only collect 1^{st} rays and neglect (multiple) reflections inside the crystal (**verify with proper ray tracing**)

  ESR reflects better than 98% (neglected for now): even after 10 bounces we still have 0.98^10 > 80% reflection

- We collect (lens with f# <= 1): pi (50mm/2)^2 / (4pi (760 mm)^2) = 1.1 x 10^-3

  ➤ 30 * 10^3 (photons/MeV) * 10 (MeV) * 10^-3 (collection) = 300 photons collected

- QE: 50%, i.e., we collect 150 electrons in the camera wells

- Number of pixel illuminated on the camera: (0.5mm / 14.18)^2 is the size of one LYSO pixel on the camera sensor (6.5 micron x 6.5 micron camera pixel size):

  ➤ (0.5mm / 14.18)^2 / (6.5 micrometer)^2 = 30 pixel are illuminated

1. Spec Chart

Product number	C13440-20CU
Imaging device	sCMOS
Cell (pixel) Size (μm²)	6.5×6.5
Pixel Array (horizontal by vertical)	2048×2048
Effective Area (horizontal by vertical in mm)	13.312×13.312

Peak Quantum Efficiency (QE)*1	82 % @ 560 nm
Dynamic Range*1	37 000 : 1

	USB 3.0	With Optional Camera Link Board for PC
Readout Noise (N^r) median in electrons slow scan*1	0.8 @ 30 fps	0.8 @ 30 fps
Readout Noise (N^r) rms in electrons slow scan*1	1.4 @ 30 fps	1.4 @ 30 fps
Readout Noise (N^r) median in electrons standard scan*1	1.0 @ 40 fps	1.0 @ 100 fps
Readout Noise (N^r) rms in electrons standard scan*1	1.6 @ 40 fps	1.6 @ 100 fps
Maximum Full Resolution Frame Rate (fps)	40	100

Cooling Temperature Readout	Yes
Dark Current (electrons/pixel/s) – Air Cooled to -10 °C	0.06
Dark Current (electrons/pixel/s) – Water Cooled to -10 °C	0.06
Dark Current (electrons/pixel/s) – Water Cooled to -30 °C	0.006
Full Well Capacity in electrons*1	30 000

ORCA Flash v4 specs

SNR is a simple ratio of the total signal to the total noise. For microscope cameras, the equation looks like this:

$$SNR = \frac{QE * S}{\sqrt{F_n{}^2 * QE * (S + I_b) + (N_r/M)^2}}$$

where

- QE = Quantum efficiency
- S = Photons/pixel
- Fn = Noise factor
- Ib = Background
- Nr = Readout noise
- M = EM gain

Hamamatsu SNR guide

We assume another factor of 50% to account for any other losses: total signal: 75 electrons

Readout noise for 30 pixels (summed signal):
sqrt(30 * 1.4^2) = 7.7 electrons

Photon shot noise (all photons per LYSO pixel):
sqrt(75) = 8.7 electrons

SNR: 75 / sqrt(7.7^2 + 8.7^2) = 6.5