# Metalenses for the detection of scintillation light from noble elements

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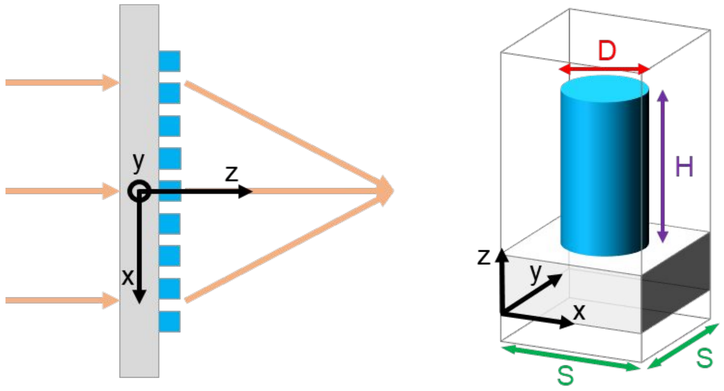
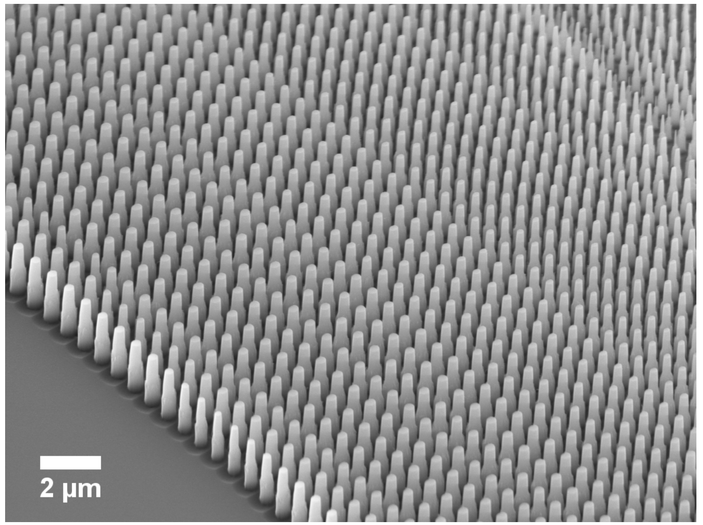
# Metalenses

Arrays of subwavelength-spaced dielectric nanostructures on a substrate serving as phase shifters to focus incident light.

> M. Khorasaninejad *et al.*, *"Metalenses at visible wavelengths: Diffraction-limited focusing and subwavelength resolution imaging"*, Science **352** (2016) 1190.




Optimized for specific light wavelengths, they have been shown to work with high efficiency above 260 nm. It should be possible to extend their range to even shorter wavelengths.




They can be fabricated with different materials (e.g. $SiO_2$, $TiO_2$, GaN) using techniques such as deep-ultraviolet lithography, allowing mass production at low cost.

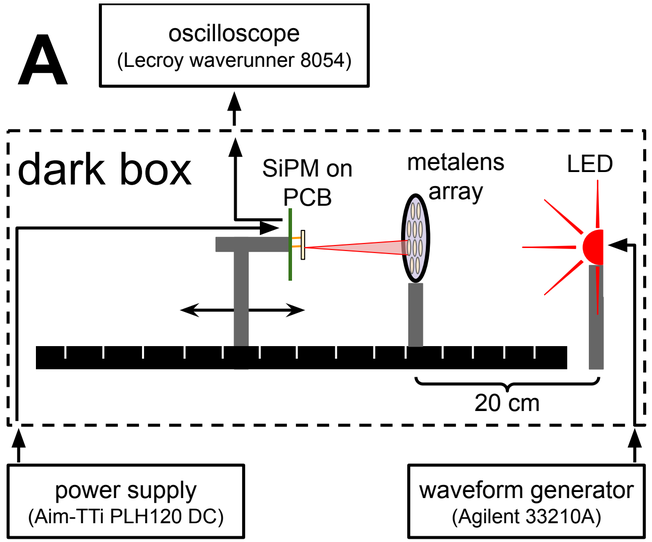
# Initial R&D

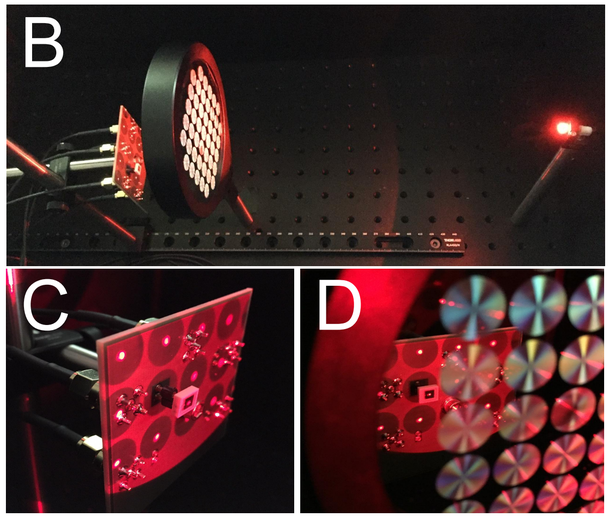
In collaboration with the Capasso Group (SEAS, Harvard), we've studied the increase in light collection efficiency (at 630 nm) of silicon photomultipliers of various sizes coupled to a metalens of 1 cm diameter:

> A.A. Loya Villalpando, J. Martín-Albo, W.T. Chen, R. Guenette, C. Lego, J.S. Park, F. Capasso *"Improving the light collection efficiency of silicon photomultipliers through the use of metalenses"*, arXiv:2007.06678.

Light collection efficiency shows a complex dependency with the distance between SiPM and metalens (due to the existence of several foci) and the sensitive area of the SiPM.

We demonstrate an increase in light collection by a factor 6–7 when using a metalens to focus light onto a SiPM with an active area of 1.3×1.3 $mm^2$.



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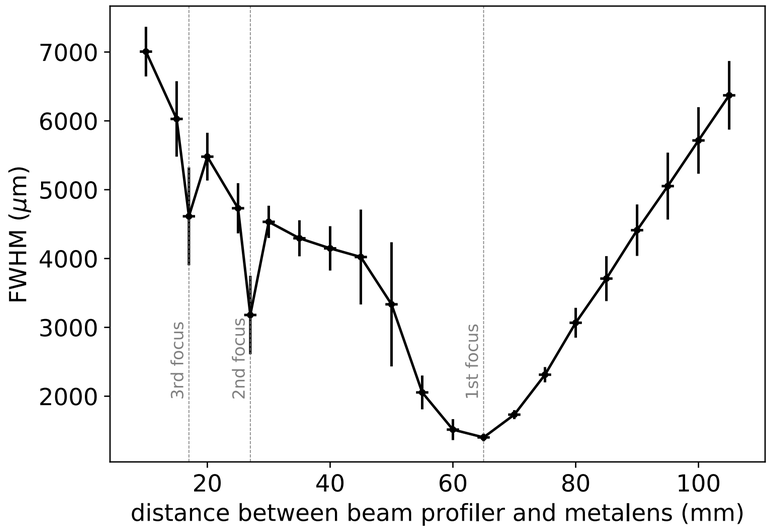
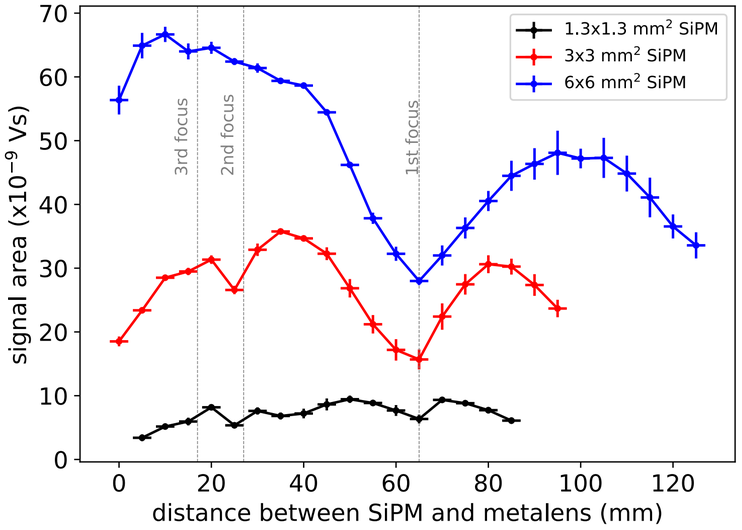
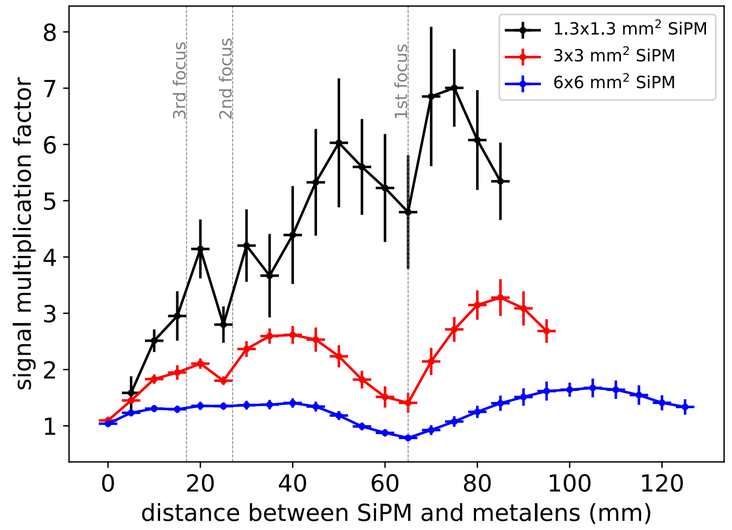



A.A. Loya Villalpando *et al.*, arXiv:2007.06678

# Applications

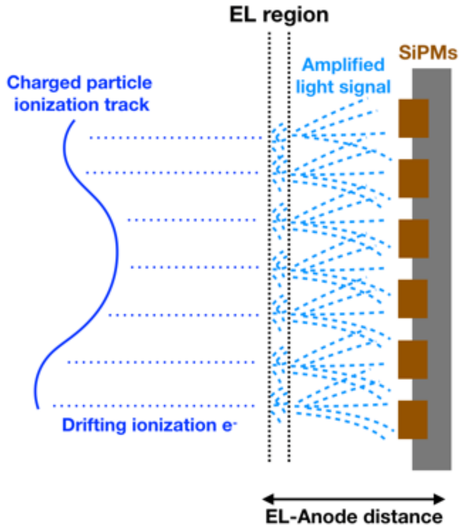
Metalenses are very versatile devices, allowing for unprecedented control over the wavefront of transmitted light.

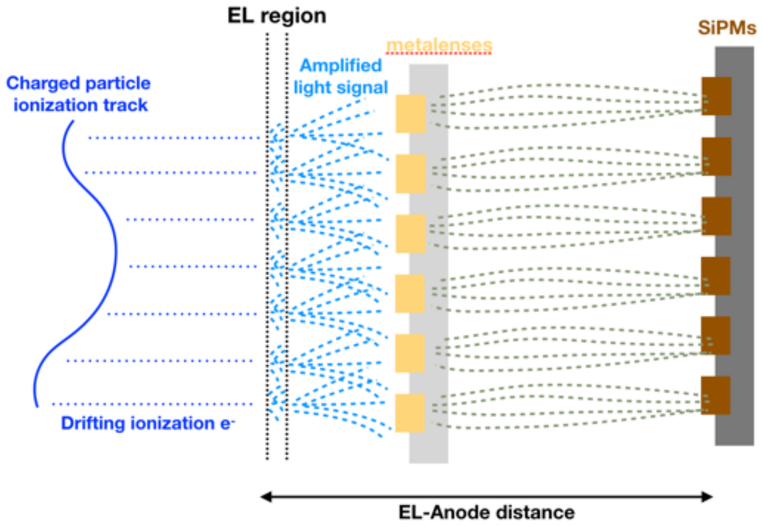
Their design could be tailor-made for the detection of scintillation light in xenon and argon detectors, in either the VUV or the blue range of the spectrum.

Mass production should make them affordable for even the largest detectors.

Two possible applications, for instance:

- Focusing of VUV secondary scintillation (electroluminescence) in an optical TPC.
- Reduction of the number of readout sensors in large-area photodetectors (e.g. X-ARAPUCA).



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