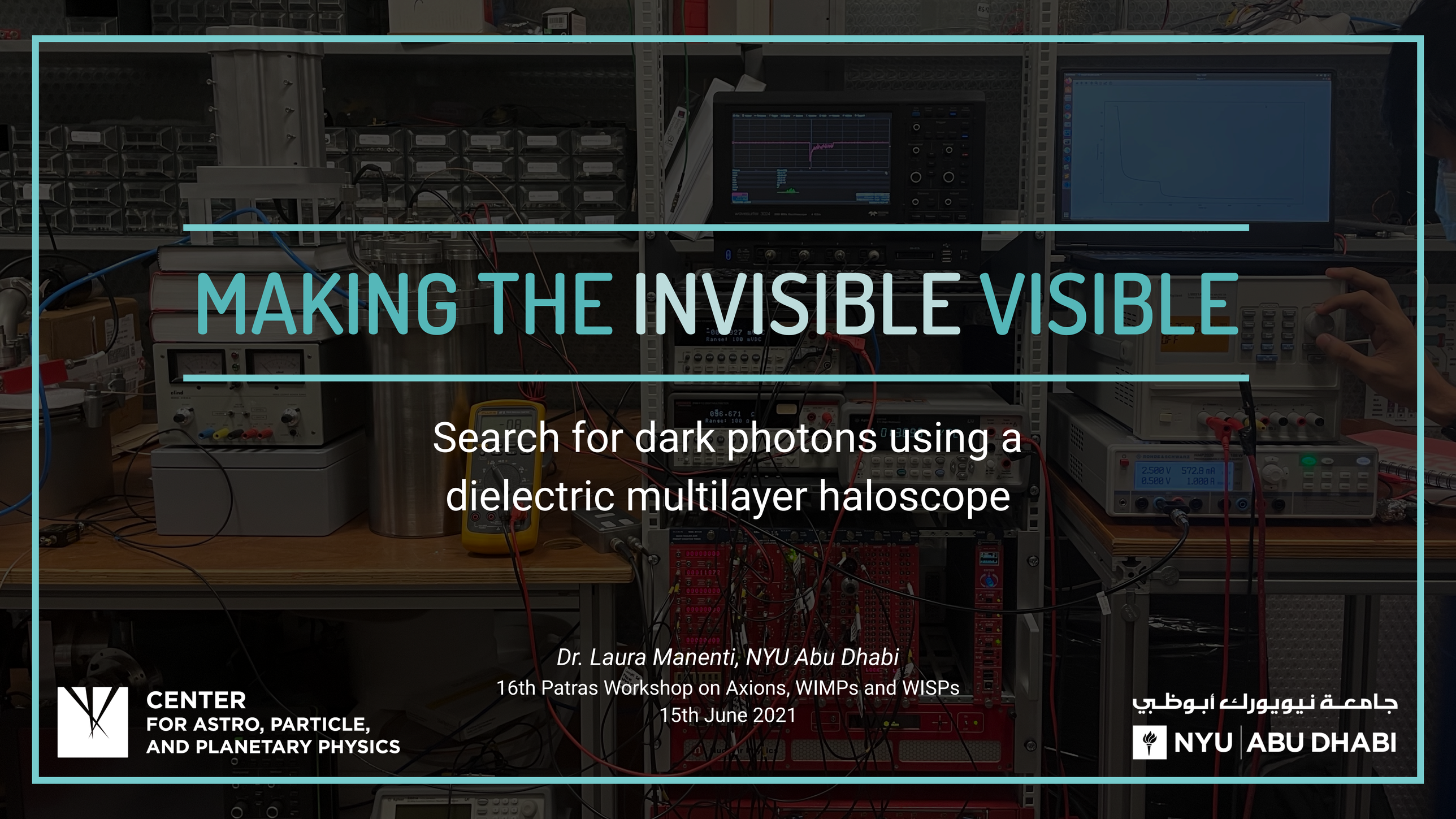

# MAKING THE INVISIBLE VISIBLE

## Search for dark photons using a dielectric multilayer haloscope

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16th Patras Workshop on Axions, WIMPs and WISPs

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CENTER FOR ASTRO, PARTICLE, AND PLANETARY PHYSICS

جامعة نيويورك أبوظبي

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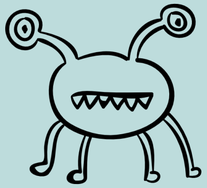
# INTRODUCTION

## DARK MATTER

While the existence of dark matter is motivated  by its gravitational coupling to the Standard Model, we (mostly) search for it on its presumed weak interaction.

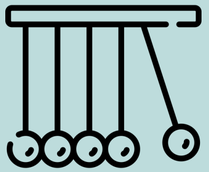


## WIMPS

Weakly Interacting Massive Particles have been highly favourable candidates. Several experiments have been searching for them in last couple of decades.

## DARK PHOTON

So far… nothing has been detected yet.
Interest in a dark sector—dark because completely neutral under SM interactions—has increased over the past few years. The dark photon is a hypothetical new boson belonging to the dark sector.



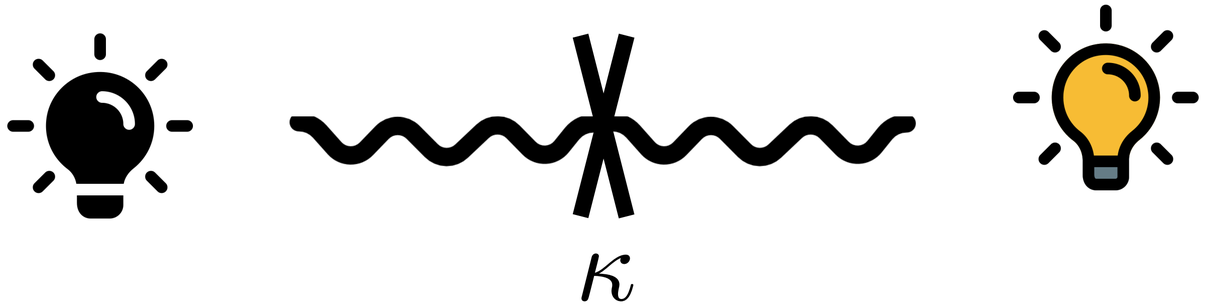
## KINETIC MIXING

The dark photon can be detected because of its kinetic mixing with the SM photon (vector portal).

$$\mathcal{L} = \mathcal{L}_{SM} - \frac{1}{4}(F'_{\mu\nu})^2 + \frac{\epsilon}{2}F'_{\mu\nu}F_{\mu\nu} + \frac{1}{2}m^2_{A'}(A'_{\mu})^2$$

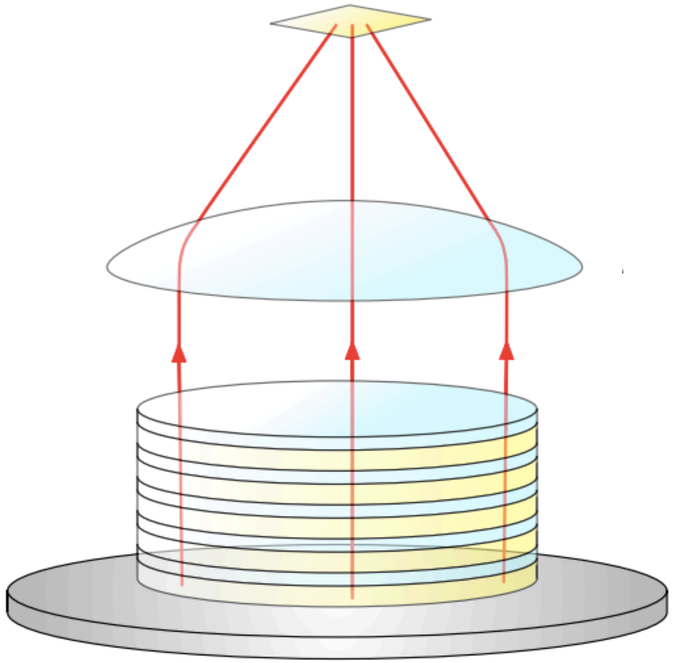
# DIELECTRIC MULTILAYER HALOSCOPE






Single-photon sensor.

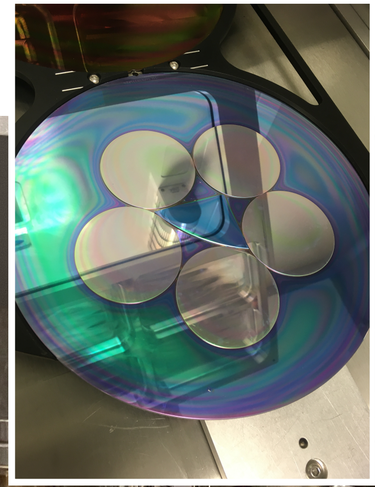
Have-wave stack of dielectric bilayers with indices of refraction n1>>n2 enable the conversion dark photon to SM photon.



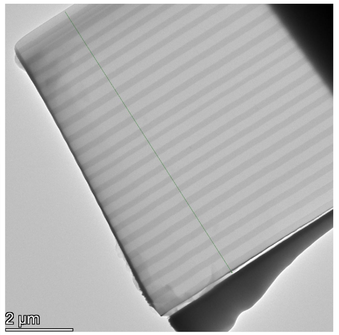
Lens for focusing the converted dark photons onto the photosensor.

Mirrored substrate to enhance DP to SM photon conversion.

# THE SETUP

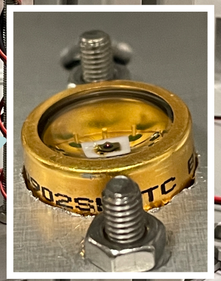


Stack

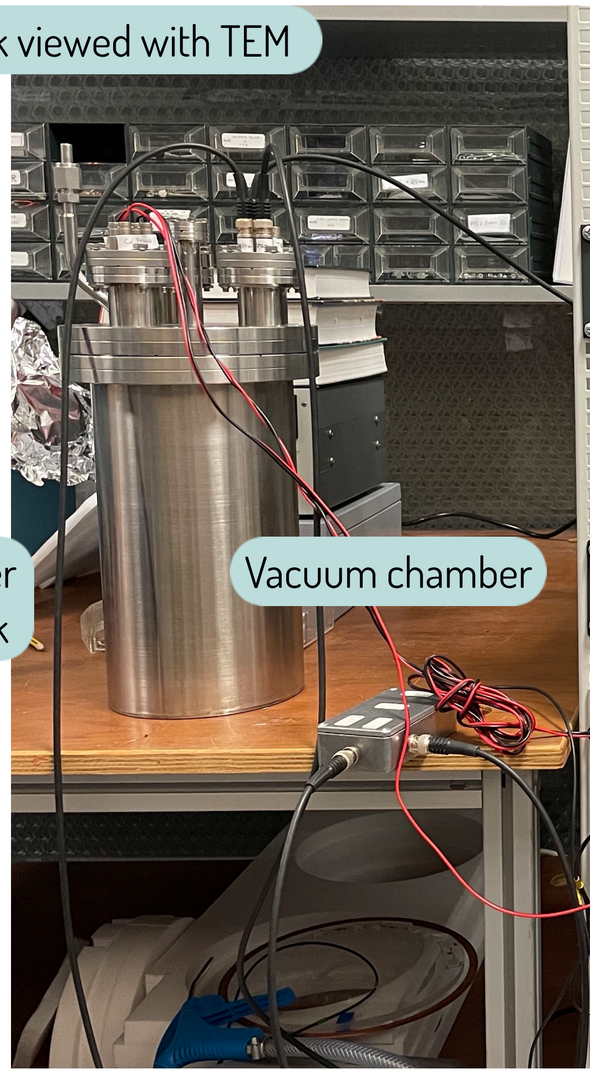



Stack viewed with TEM

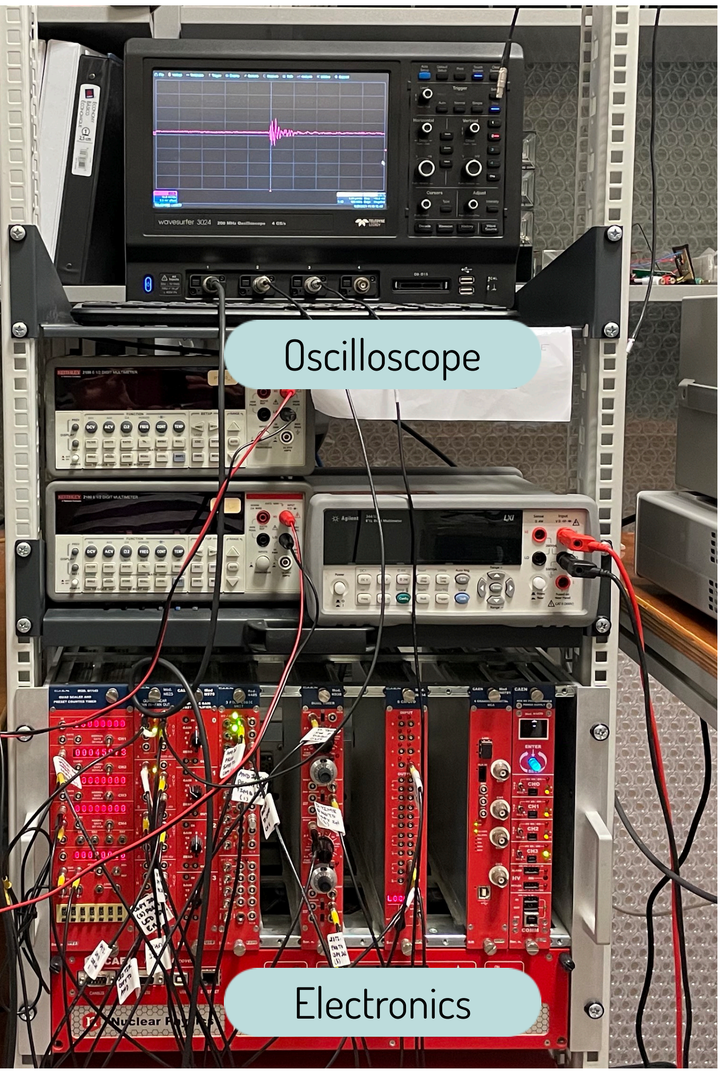
Micrometer holder for lens and stack



SPAD



Vacuum chamber



Oscilloscope

Electronics

# THE EXPERIMENT

## “OFF” MEASUREMENT

1. No stack present gives measurement of background.

## “ON” MEASUREMENT

2. Stack present gives measurement of signal+background.

## PLACE LIMITS

3. Compute the one-sided upper limit at 90% confidence level.

# PROJECTED EXCLUSION LIMITS

## "OFF" MEASUREMENT

1. No stack present gives measurement of background.

## N/A

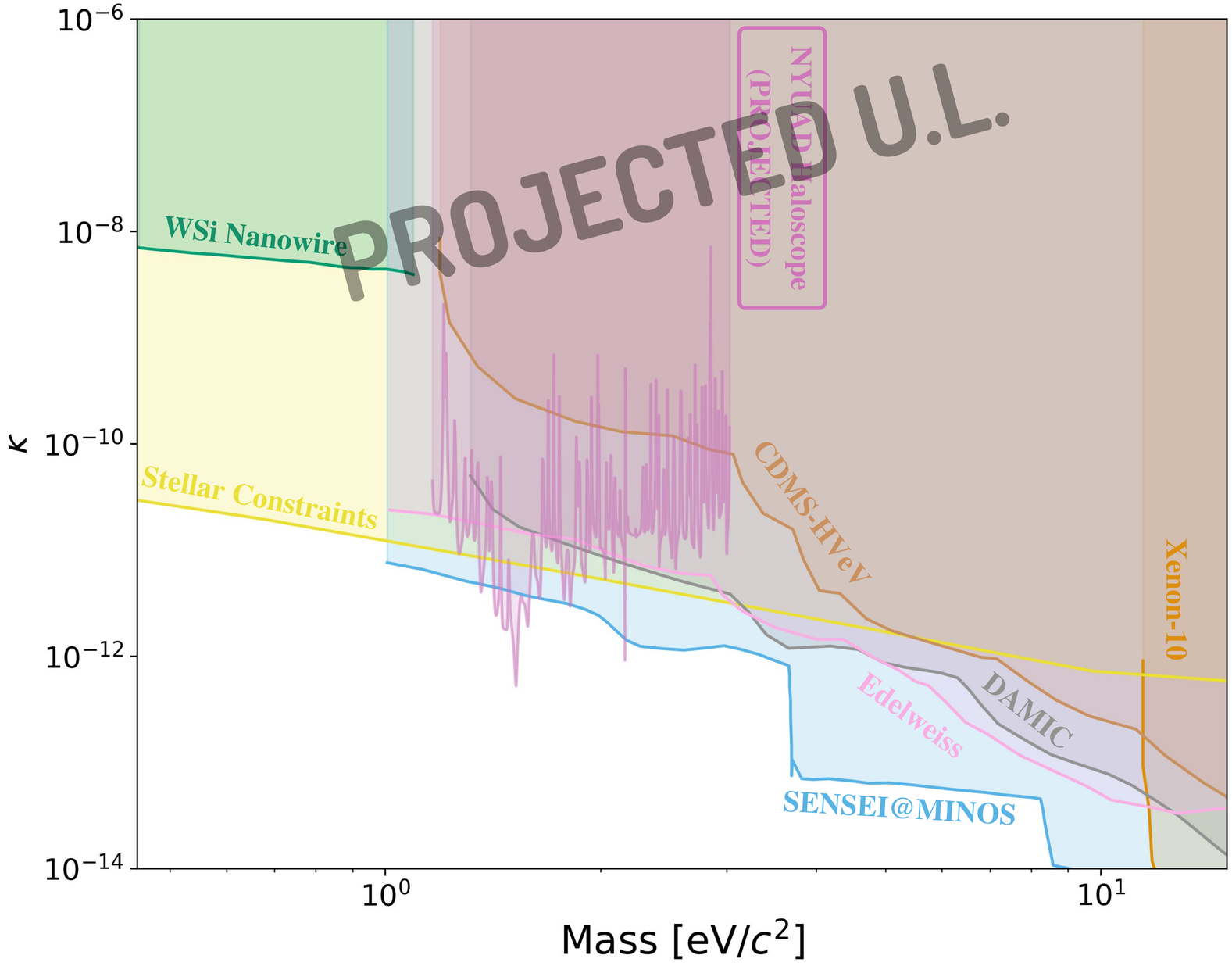
2. Assume no signal, i.e. $n_{on} = n_{off}$

## PROJECTED LIMITS

3. Compute the one-sided upper limit at 90% confidence level for a no signal measurement.

# PROJECTED EXCLUSION LIMITS

N.B. Colorblind-friendly plot thanks to “color blind” palette from the seaborn library in Python



# CONCLUSIONS AND OUTLOOK

**First-ever prototype** of a multilayer dielectric haloscope in the 800 nm range

**Economic** prototype (~$20,000) , that can be run in a standard physics lab with no special requirements.

**Mechanical assembly** developed and tested. The same setup will be sued for the second stage of the experiment.

**Complete the “on measurement”** to place experimental upper limits on the mixing constant.

We are working with collaborators at INRiM (Turin, Italy) to develop a **Transition Edge Sensor** (TES) that will have dark count rates of the order of $10^{-4}$ Hz.