DARK PHOTON SEARCH WITH OPTICAL HALOSCOPES

Dr. Laura Manenti
NYUAD and WIS Collaboration
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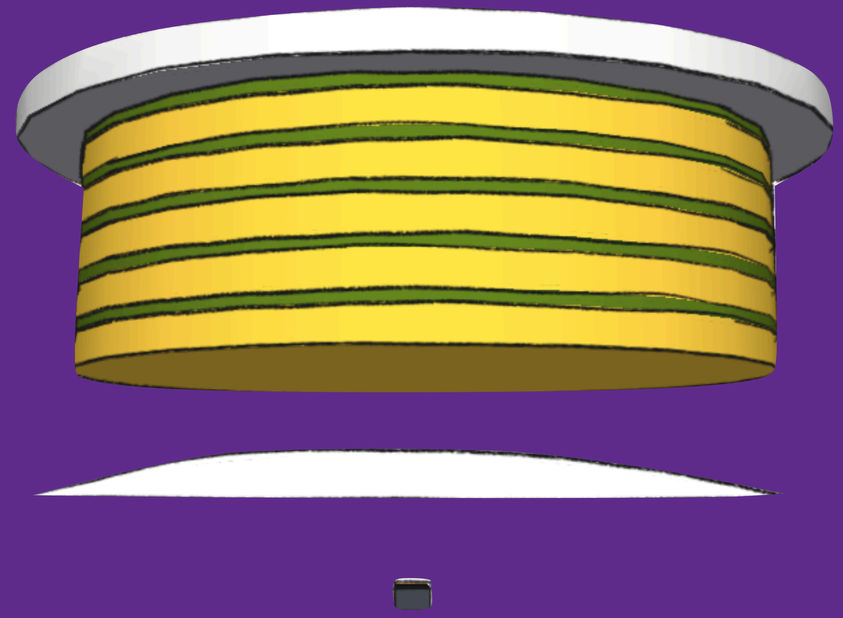

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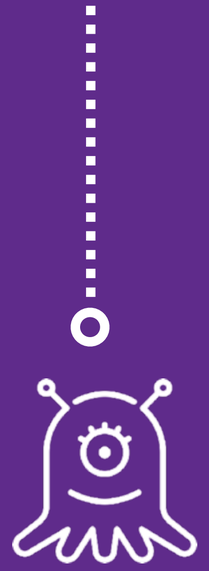


Dark Photons

Dark Photons

Among the **most favourable candidates** for DM are WIMPs.

But what about new “species” of light dark matter < GeV?

Many of the existing experiments that look for light DM are not sensitive to DM masses far above the **microwave range.**

We extend the search to higher masses, from 0.1 to 10 eV.

In particular, we look for dark photons around 1.5 eV.

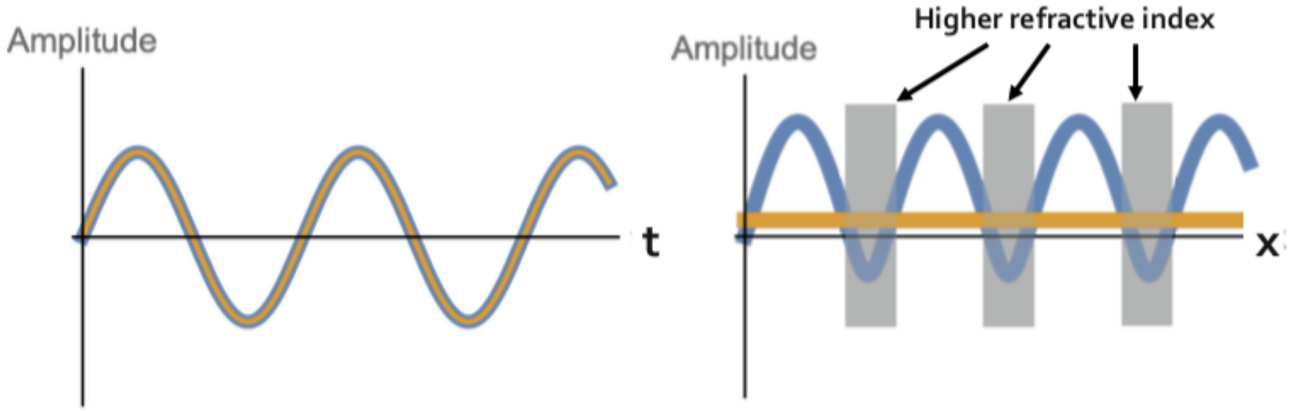
How?

Dark Photon conversion

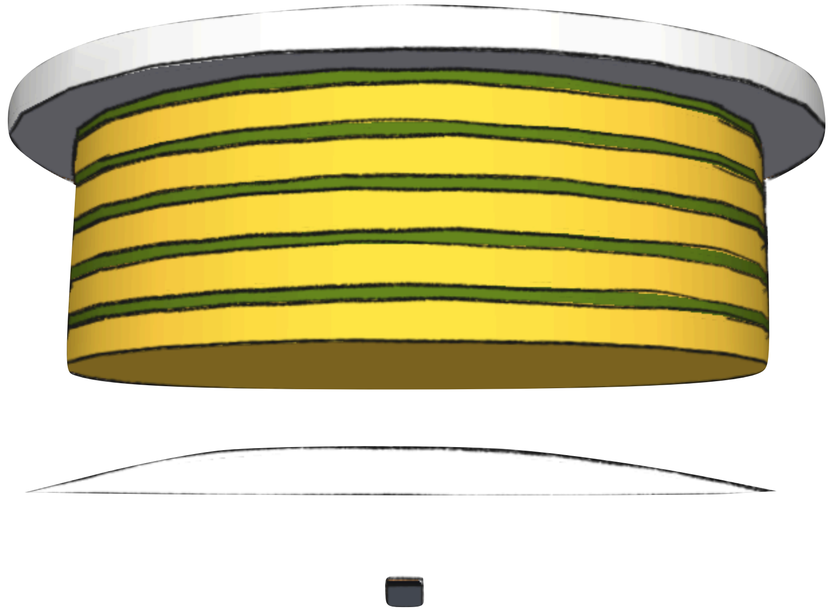
Dark Photon conversion

Dark Photons are converted to SM (detectable) photons.

A periodic index of refraction corrects the momentum mismatch between the DP and the SM photon, such that the electric field does not integrate to zero.



Multilayer optical haloscopes

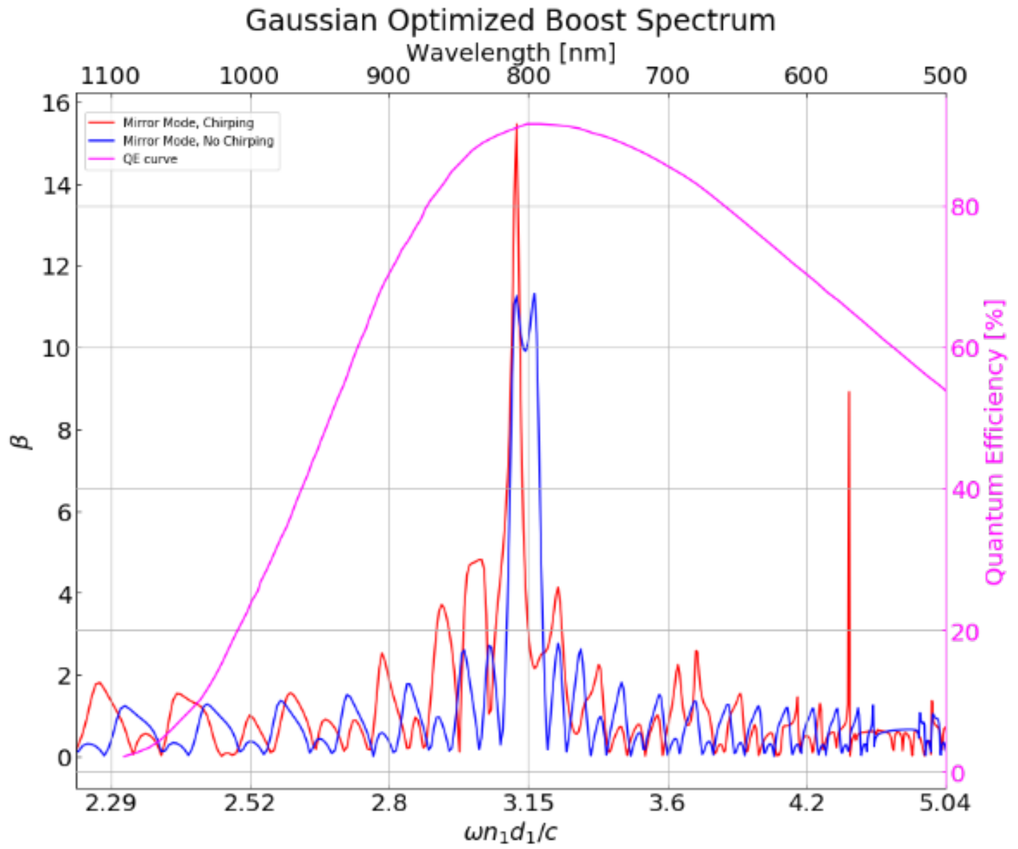


- Mirror
- Dielectric bilayers, with high contract indices of refraction n_1 and n_2 (e.g. SiO2 and Si3N4, with indices of 1.46 and 2.05 respectively)
- Lens
- Photon detector (QE peaked at the DP mass)

Multilayer dielectric haloscope

Boost spectrum

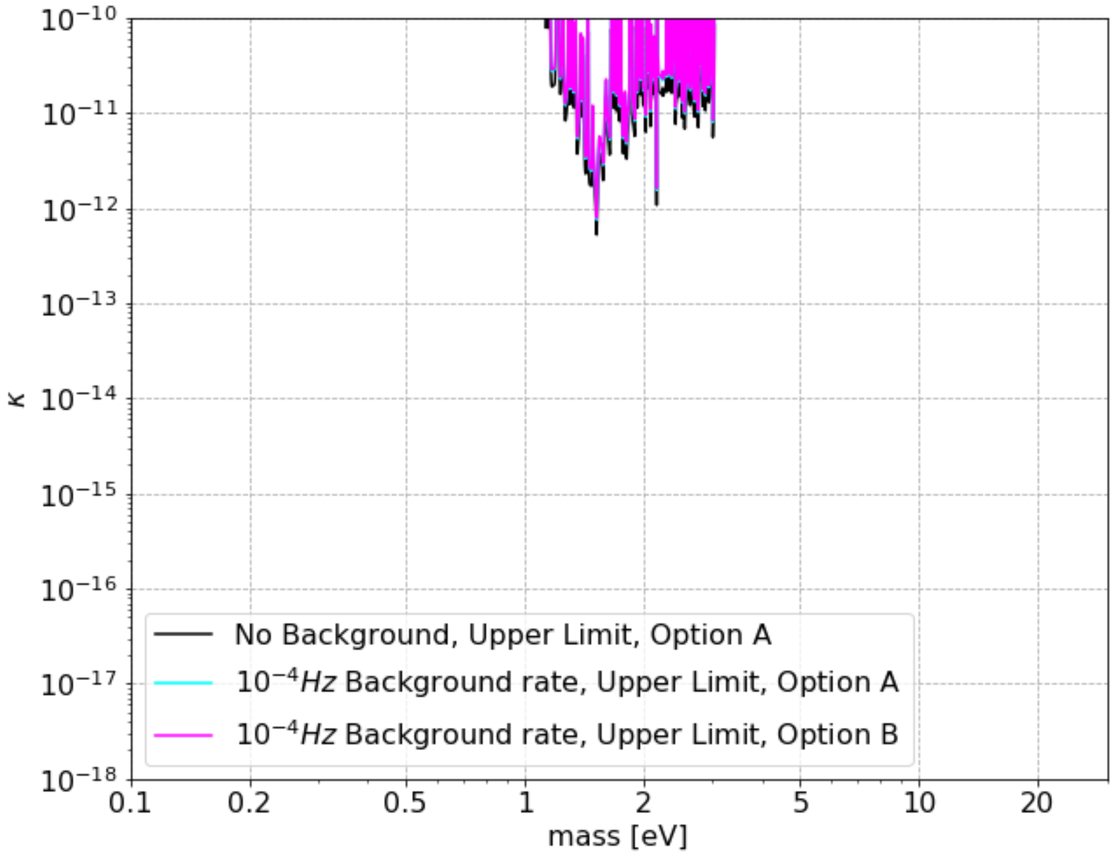
Boost factor (beta) spectrum



$$\Phi = 2.6 \times f_{DM}\eta \left(\frac{1}{m}\right) (\beta\kappa)^2 [(\mathrm{eV} \times \mathrm{days})^{-1}(\mathrm{cm})^{-2})]$$

Statistical analysis

Upper limits

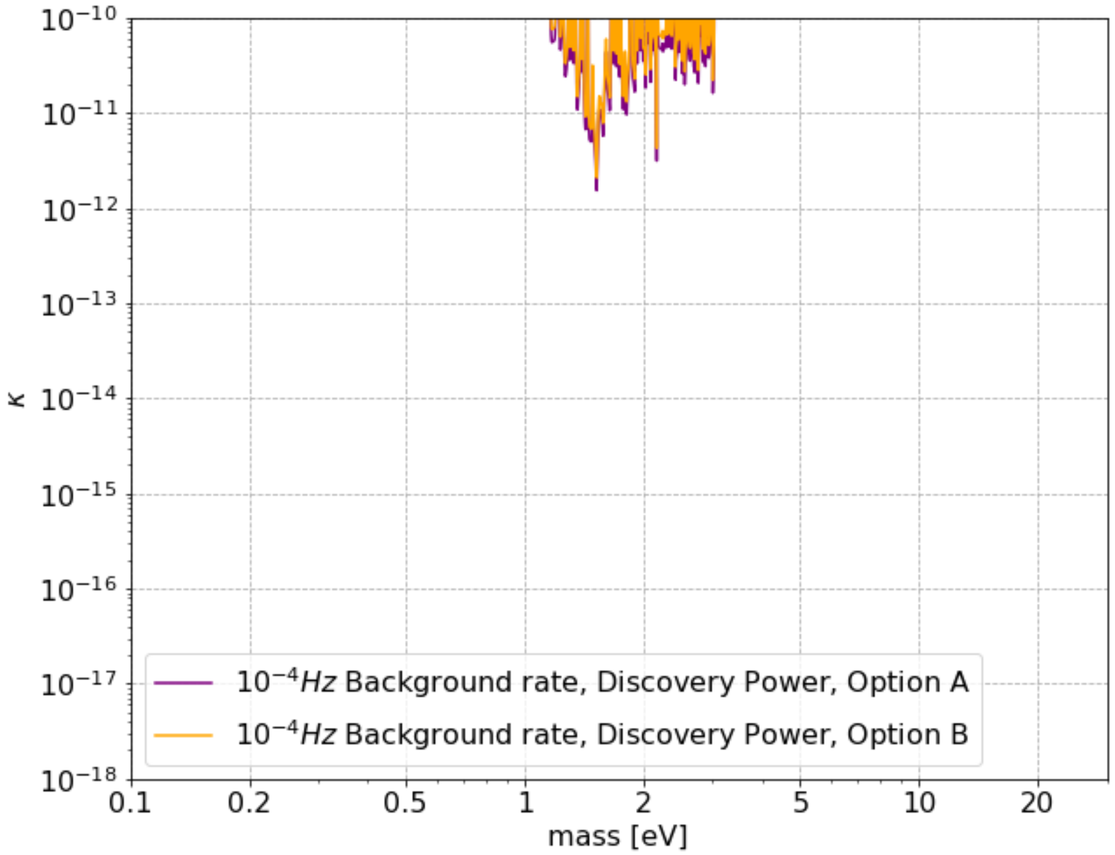


Option A: Poisson background with no uncertainty

Option B: Poisson background with uncertainty

Statistical analysis

Discovery limits

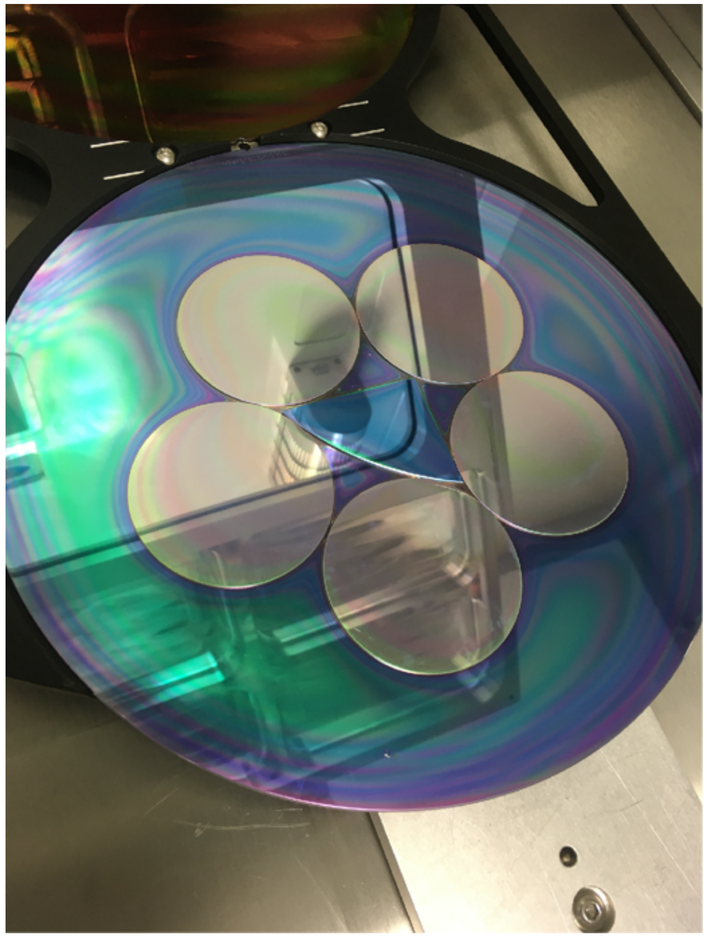


Option A: Poisson background with no uncertainty

Option B: Poisson background with uncertainty

The stack

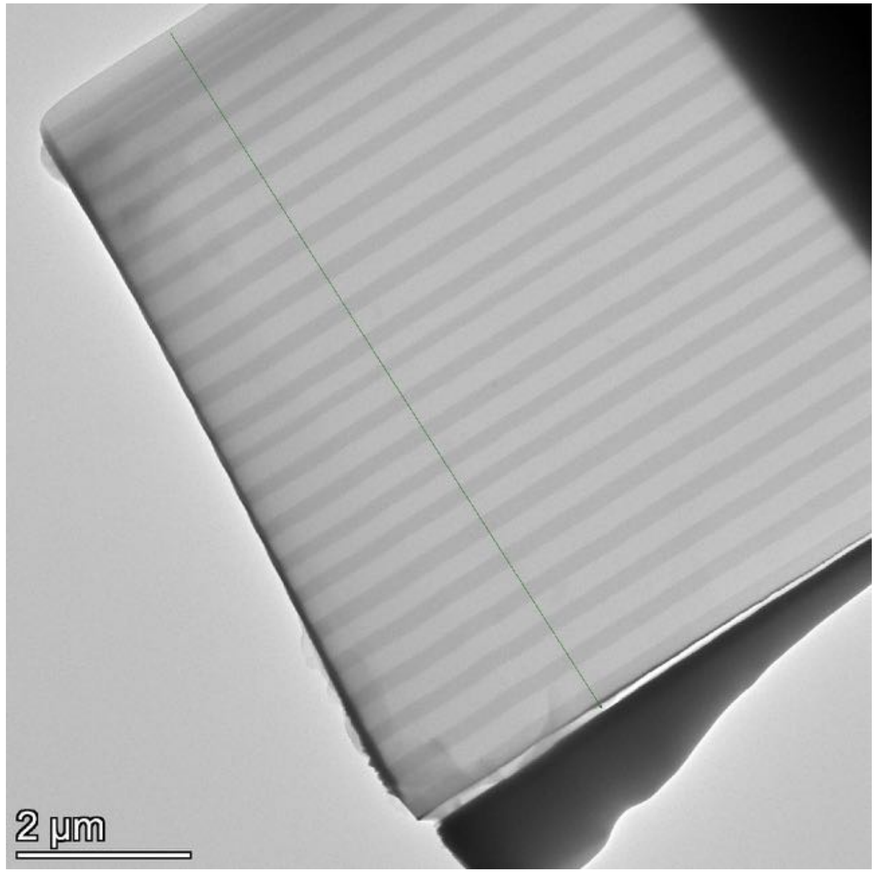
The stack

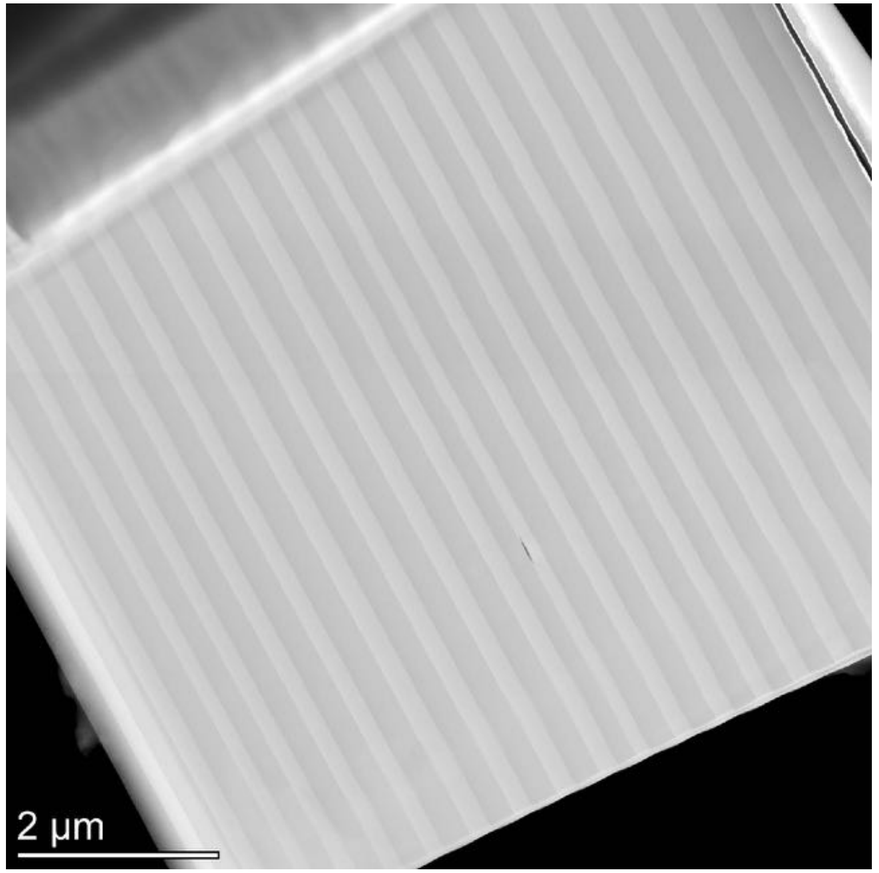


- The stack (actually 5 of them) was produced at the PoliFAB, the micro and nano technology center of the Politecnico di Milano.
- Technique used: plasma-enhanced chemical vapor deposition
- 46 layers (23 SiO_2 and 23 Si_3N_4)

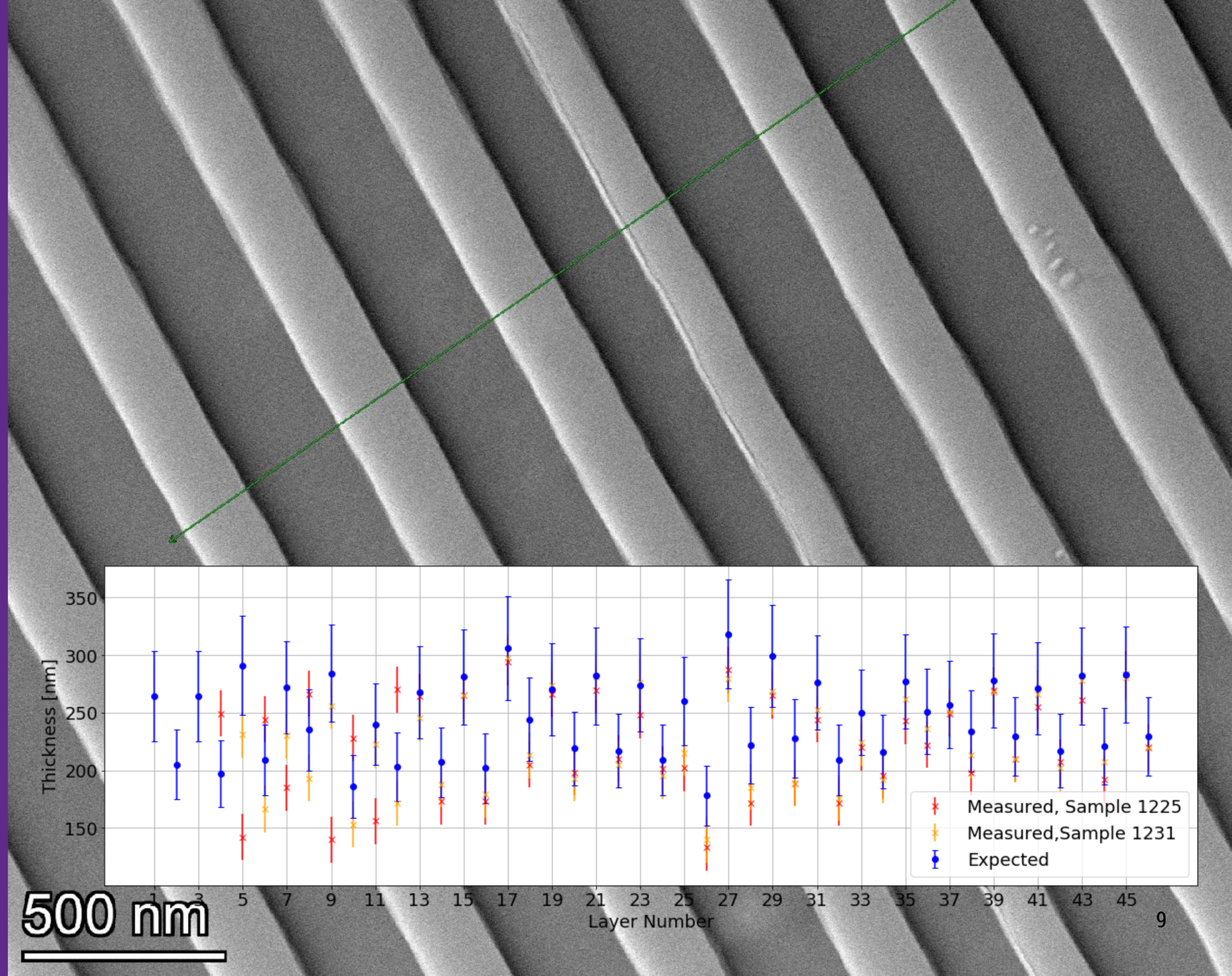
TEM analysis

TEM analysis





TEM analysis



EDAX analysis

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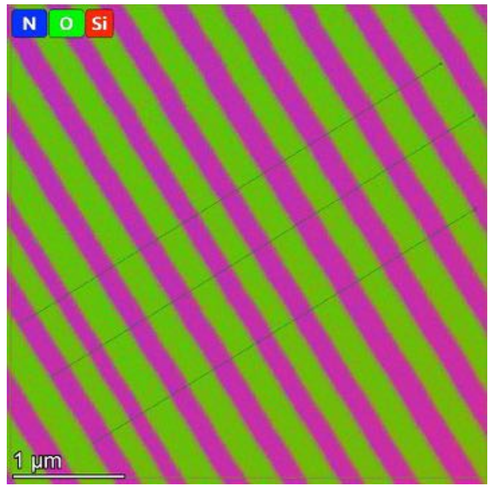

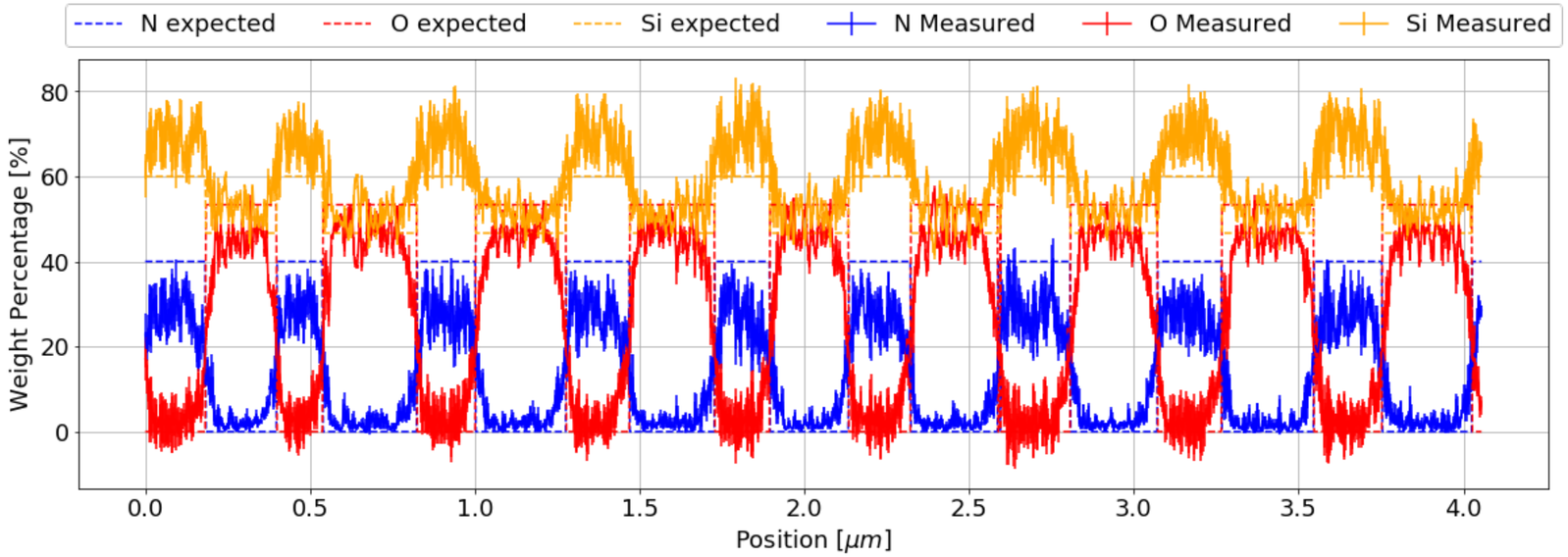

EDAX analysis

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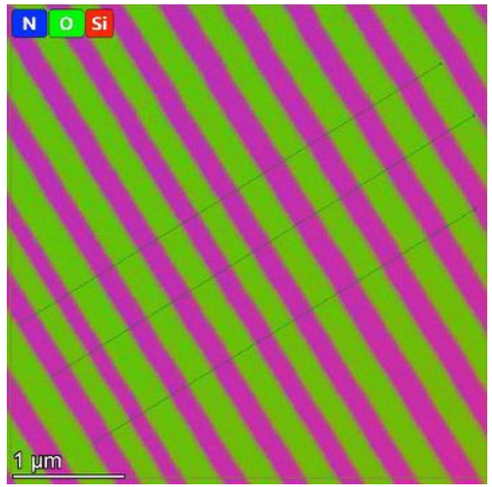
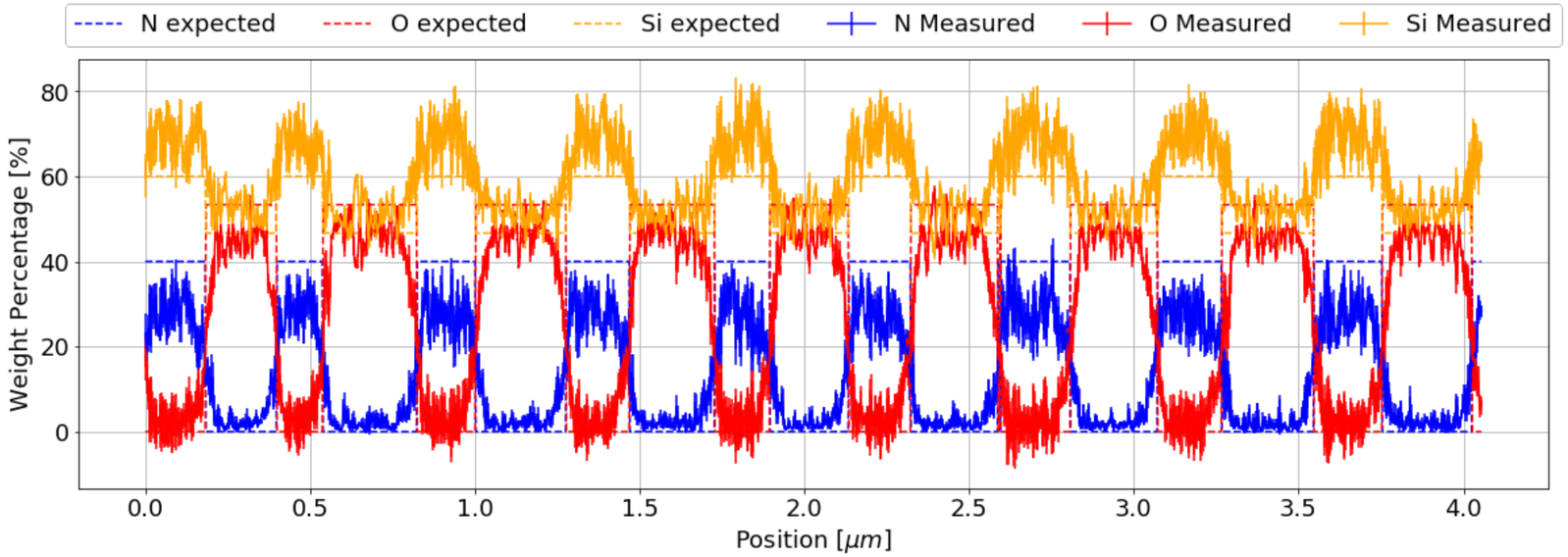
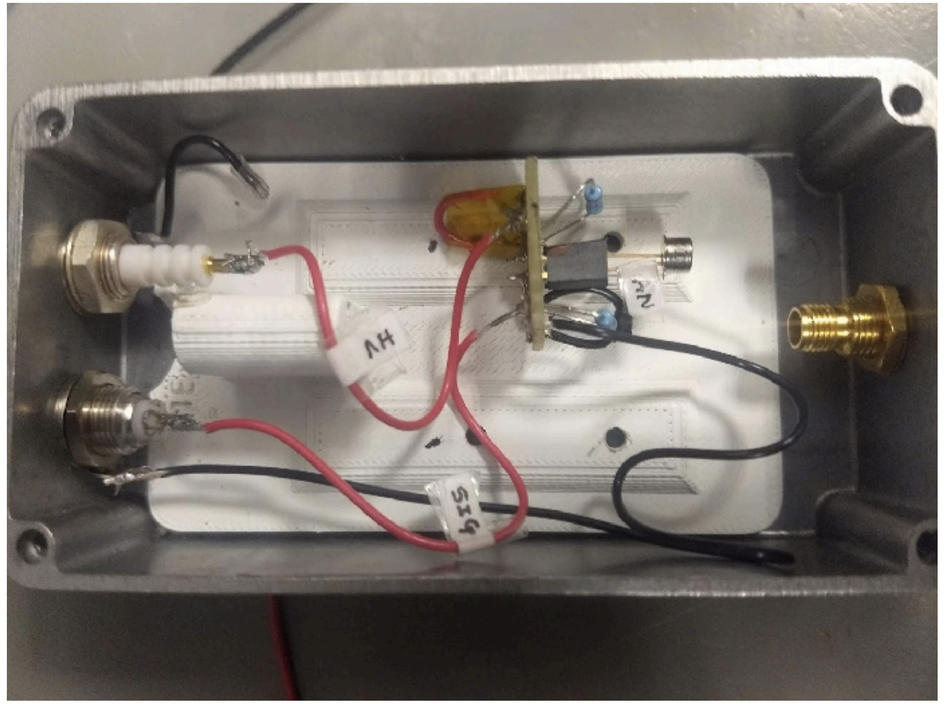
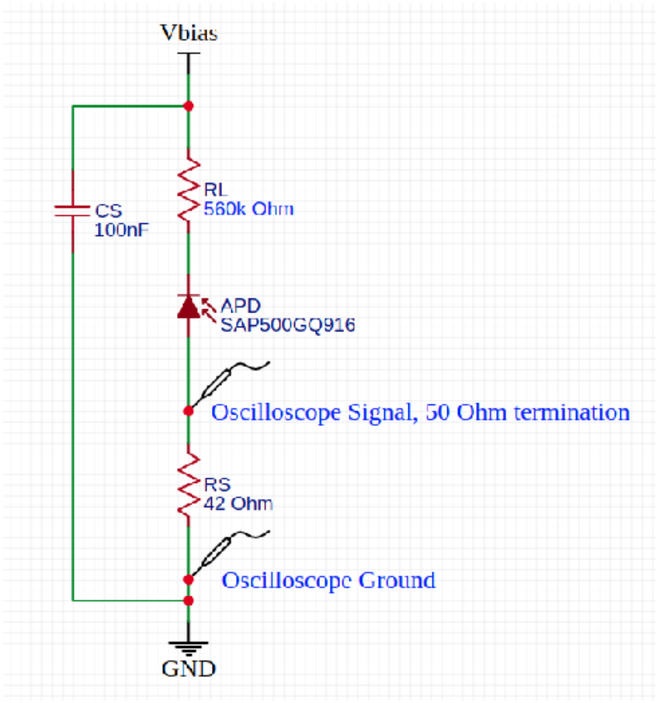


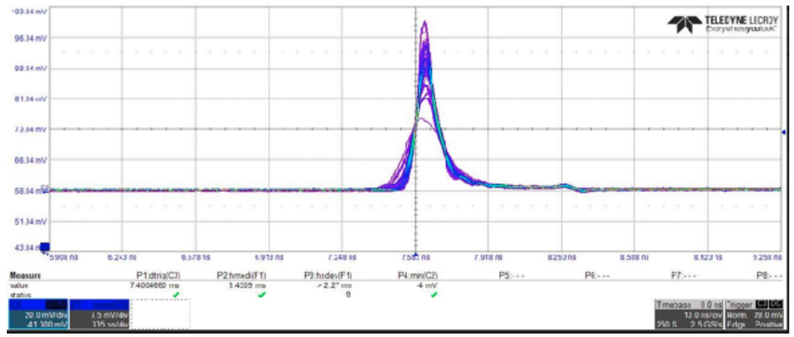


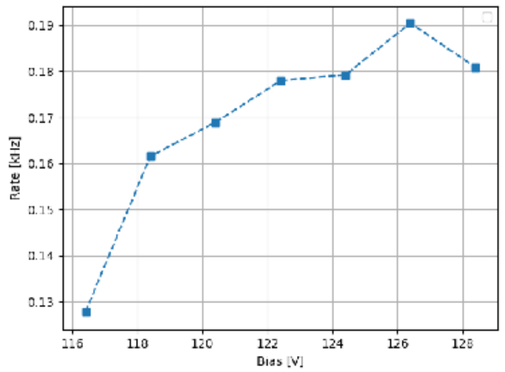
SPAD

The photosensor



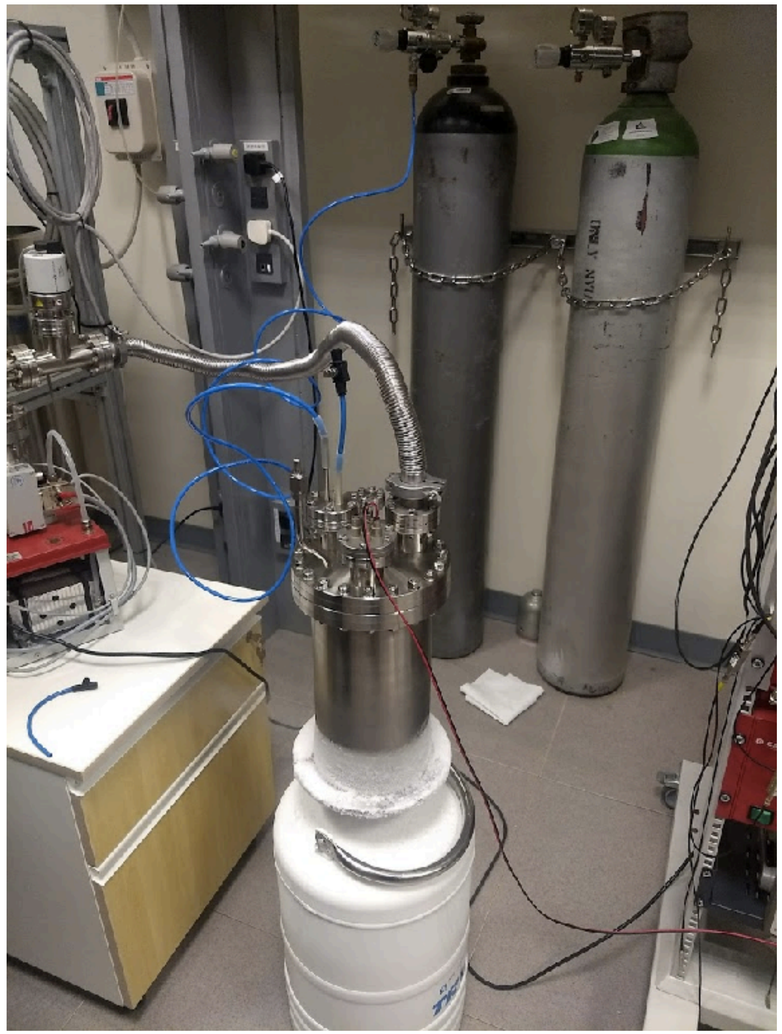






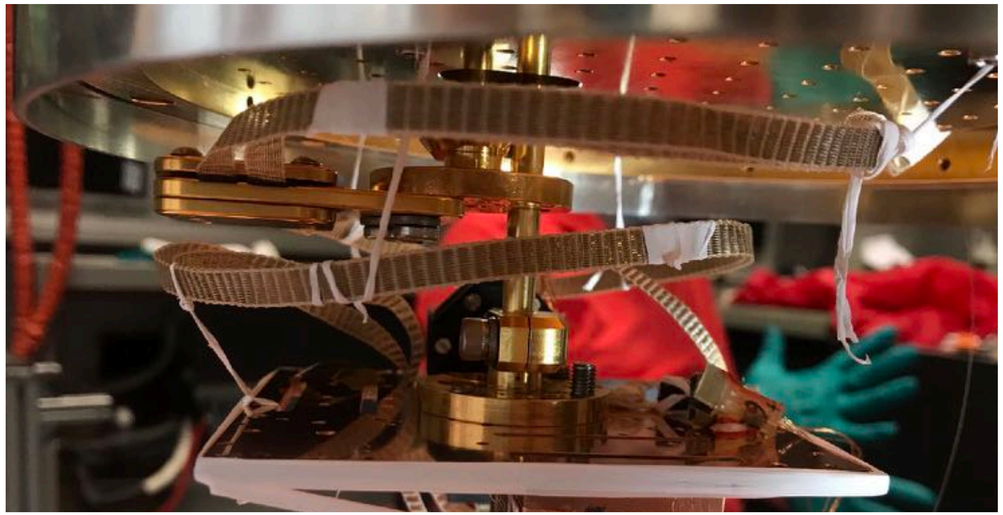
The photosensor

SPAD cryo test



Transition Edge Sensor

TES



Next steps

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- Run the full experiment using the SPAD
- Construction and characterisation of the TES
- Final experiment using the TES