Performance of AC-LGAD strip sensor designed for the DarkSHINE experiment

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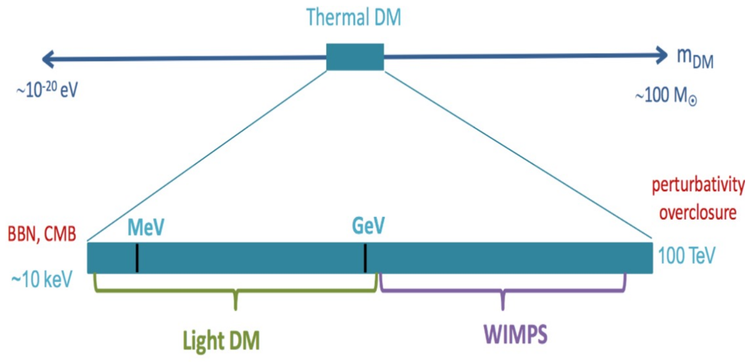
DarkSHINE Experiment

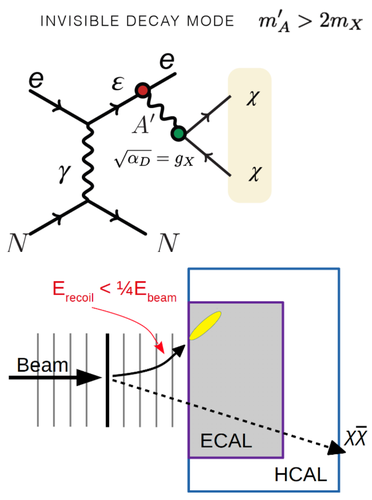
Physics motivation

Search for dark photon A': an important portal between the standard model (SM) particle and the dark matter.



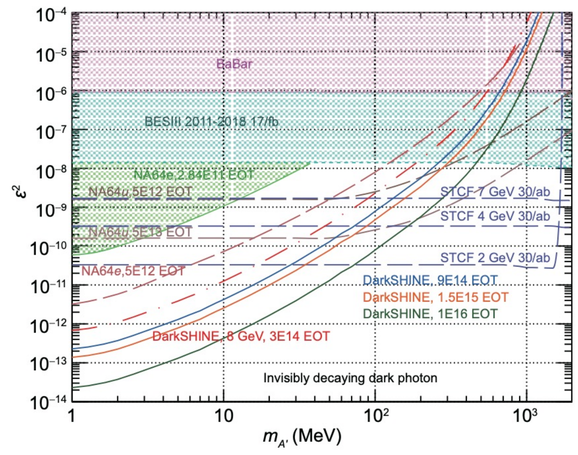
Signal signature

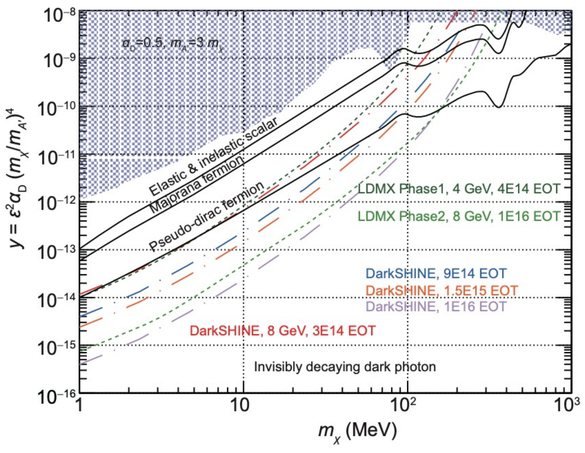
In electron-on-fixed-target experiment, dark photon decays to DM candidates, the signal behaves as missing momentum.



The DarkSHINE projected sensitivity

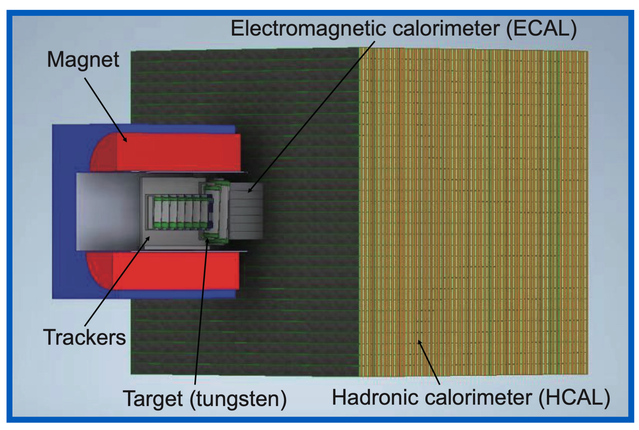
The DarkSHINE experiment will provide competitive sensitivity, which will be able to exclude most sensitive regions. Reconstruction of position and momentum of the incident and recoil electrons is crucial for this experiment.





Tracking System

DarkSHINE Detector

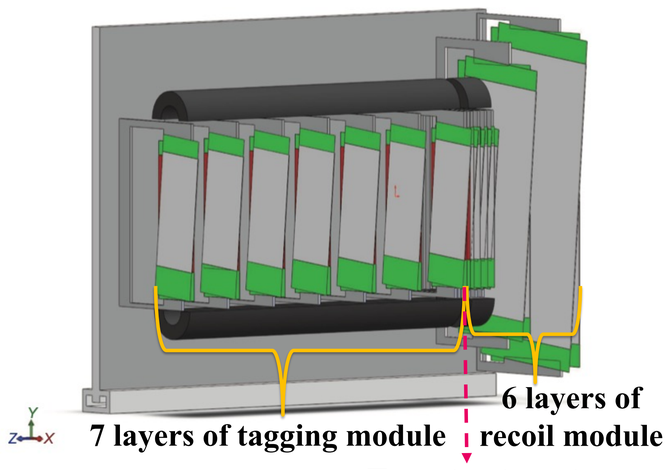


ECAL: Electron & photon. Scintillator: LYSO(Ce).

HCAL: Veto hadronic background. Scintillator w/ steel absorber.

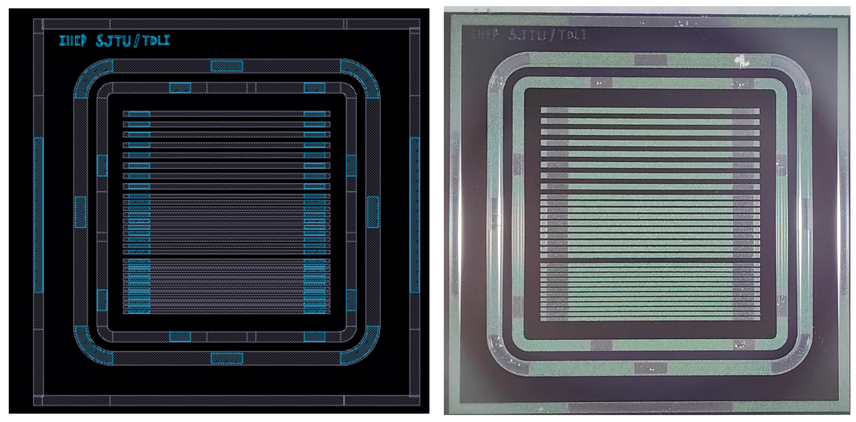
Tracker:
AC-coupled Low-Gain Avalanche Detector (AC-LGAD) silicon strip sensor.
Incident and recoil electron trackers.
1.5 T magnetic field.

Tracker



Each module: 2 layers of silicon strip sensor with a small angle **(0.1 rad)** for better position resolution.
Resolution: 10 μm(horizontal), 60 μm(vertical).

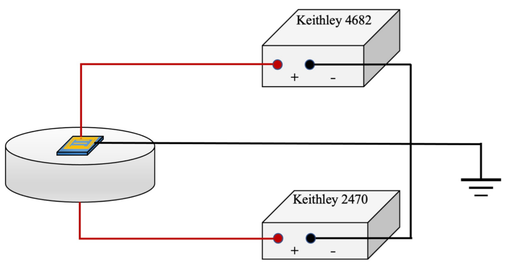
Prototype sensors



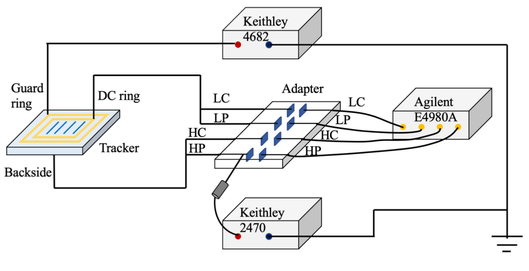
AC-LGAD silicon strip sensor 1x1 mm^2 with pitch (strip) size of 100 (50) μm, 60 (40) μm, and 45 (30) μm are designed for the DarkSHINE experiment, in collaboration with Prof. Zhijun Liang and Prof. Mei Zhao from IHEP.

Performance of Tracker Prototypes

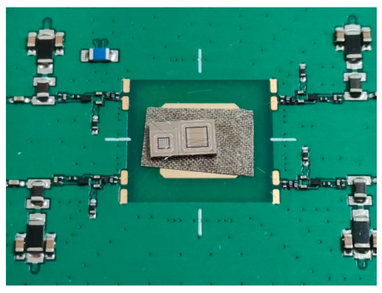
Sensor test setup



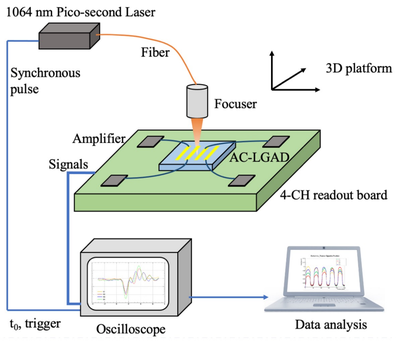
I-V test



C-V test

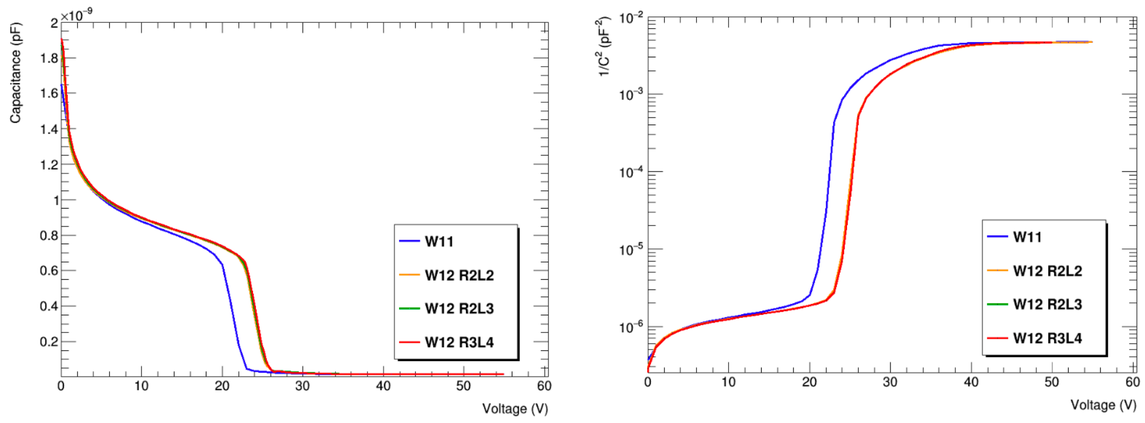


Sensor bonded to a readout board



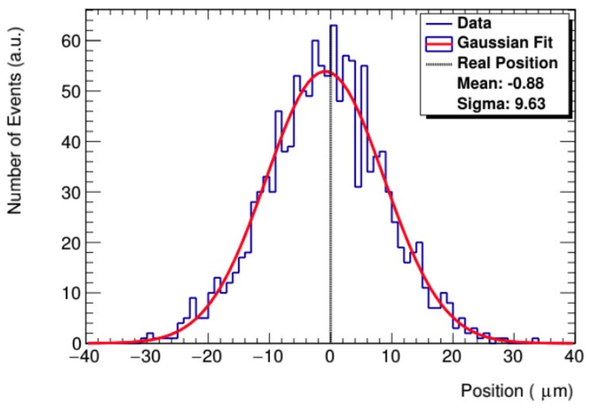
Transient current technique platform

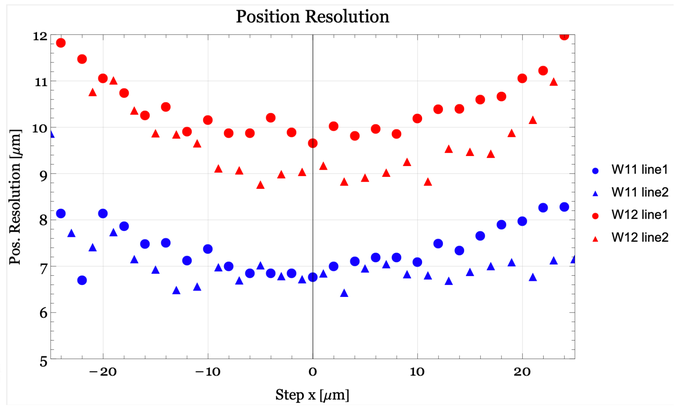
CV Performance



Capacitance-Voltage and $1/C^2$ curves of the prototype strip sensors are measured at room temperature.

Spatial resolution

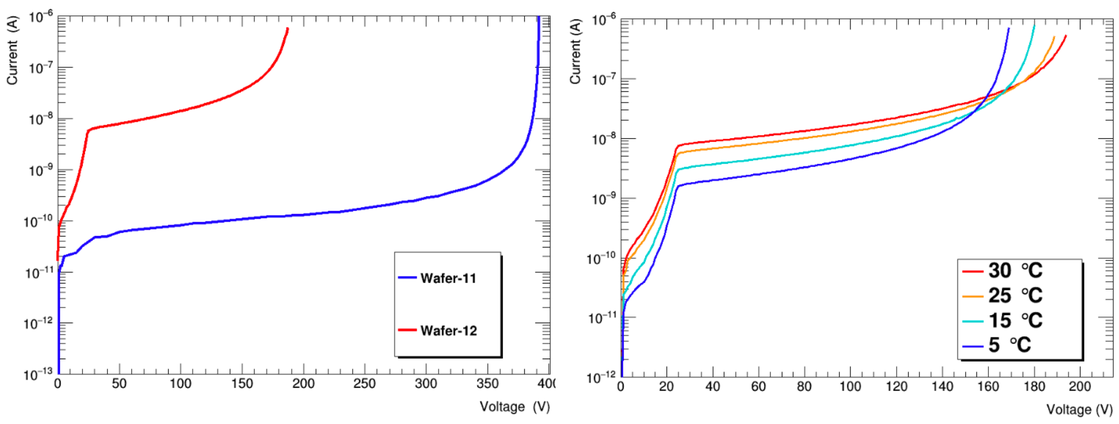




The sigma value, 9.63 μm, of the Gaussian fit is considered as the spatial resolution.

The range of spatial resolutions are 6.5 μm ~ 8.2 μm and 8.8 μm ~ 12.3 μm for wafer-11 and wafer-12 sensors.

IV Performance



Room temperature I-V performance and temperature dependency I-V performance. Wafer-11 with smaller n+ doses therefore has higher resistivity. So the working voltage of the wafer-11 (wafer-12) sensors should be set below 350 V (150 V).

References: Prospective study of light dark matter search with a newly proposed DarkSHINE experiment https://doi.org/10.1007/s11433-022-1983-8
Performance of AC-LGAD strip sensor designed for the DarkSHINE experiment arXiv:2310.13926