Characterization of VUV-sensitive SiPMs for nEXO

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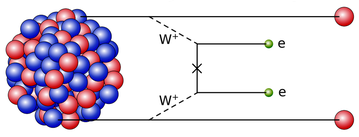
Physic beyond Standard Model?

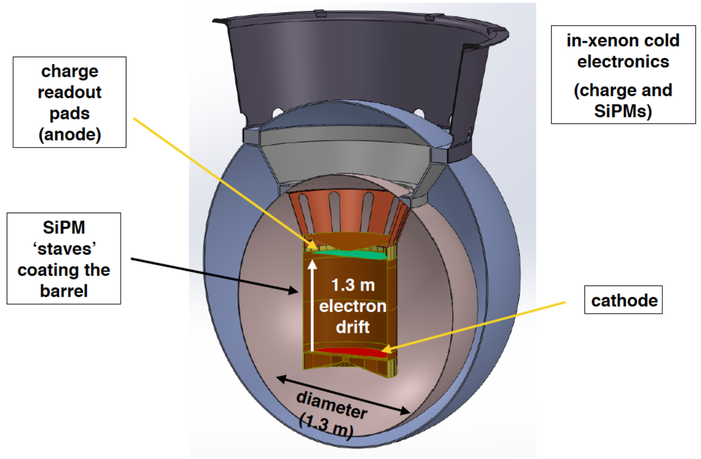
- The neutrinoless double beta decay opens window to physics beyond SM
- Are neutrinos Majorana particles?



- Current 0νββ searches are sensitive to a half life of about 10^{26} years
- nEXO plans to increase sensitivity by two orders of magnitude

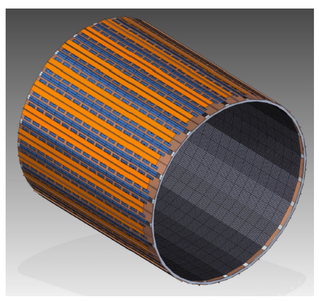
The nEXO detector

- Time-projection-chamber (TPC) filled with ~ 5 tons of liquid Xenon (LXe) – enriched to 90% in ^{136}Xe
- Cylindric barrel with a diameter and height of 1.3 m
- Detector set up in underground lab to shield from cosmic rays (likely SNOLAB, 6000 mwe.)
- Signal detection via charge readout tiles (end cap) and VUV-sensitive SiPMs (inner wall)
- Cathode set to -60 keV to produce axial drift field
- Extensive radiopurity screening to constrain BG
- Homogeneous detector & multi-parameter analysis



Light detection

- nEXO sensitivity depends on light collection efficiency and photo detection efficiency
- Inside wall covered with 4 m^2 of VUV-sensitive SiPMs
- Detection of 178 nm scintillation light in the LXe
- Goal: 1% energy resolution at Q-vlaue (2458 keV)
- Strong requirements on SiPM parameters



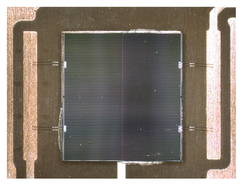
Parameters	Value
Photo detection efficiency at 175-178 nm (without AR coating measured in gas/vacuum)	>15%
Radiopurity: Contribution of photo-detectors to the overall background	<1%
Dark noise rate	<50 Hz/mm^2
Probability for correlated avalanches per parent avalance	<20%
Active area per single photo-detector	>1cm^2
Capacitance	<50pF/mm^2
Pulse width (after electronics shaping)	<100 ns

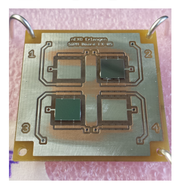
SiPM characterization test setups

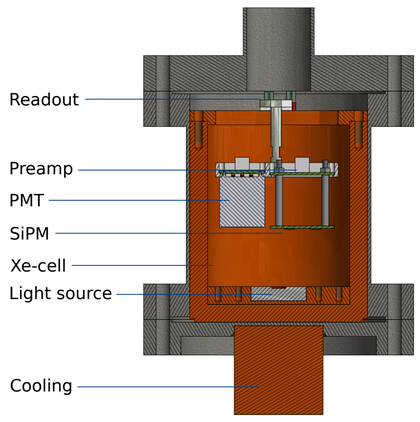
- ECAP, Erlangen (Dark noise, PDE, collab. with U.Münster for VUV reflectance)
- IHEP, Beijing (HV behaviour, VUV reflectance)
- TRIUMF, Vancouver (Dark noise, PDE)
- UA, Alabama (VUV reflectance)
- Stanford (PDE, SiPM tiles)
- UMass (PDE, LXe)

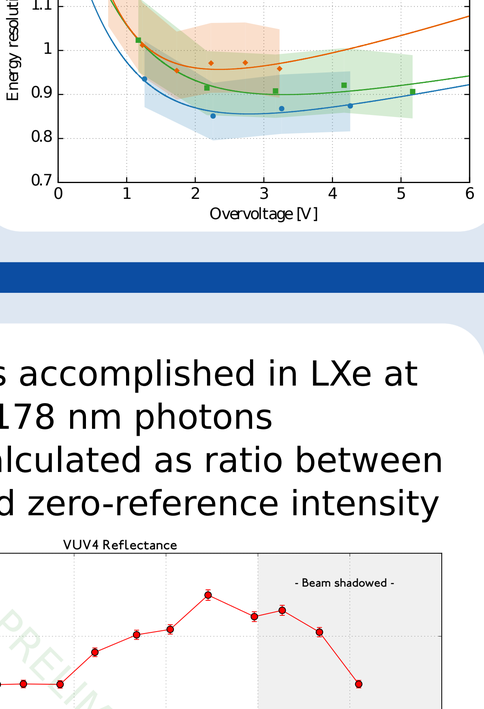
Various SiPMs

- Hamamatsu VUV3, VUV4
- FBK NUV 2016 LF & STD









Measuring procedure @ ECAP

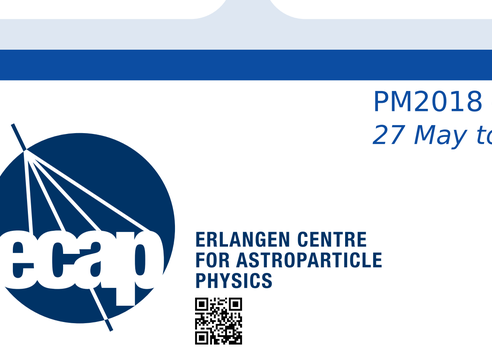
- Record SiPM pulses under dark & light conditions at -100°C
- Fit waveforms with pulse template
- Account for afterpulsing and crosstalk
- Use amplitude, timestamp, rise/fall time for further analysis

Afterpulsing

- Delayed avalanches correlated to the primary pulse
- Important nuisance charge contribution

PDE

- Efficiency to detect single photons
- Angle-, wavelength- and bias voltage-dependent

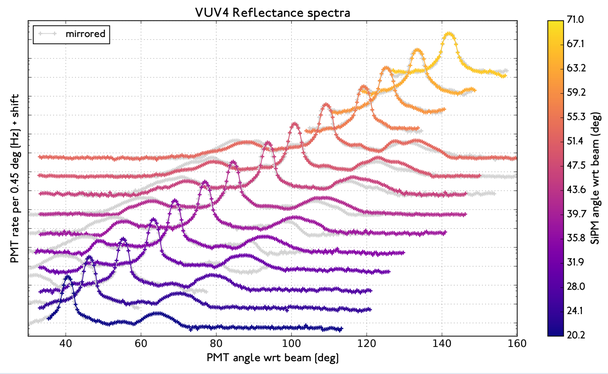


Energy resolution

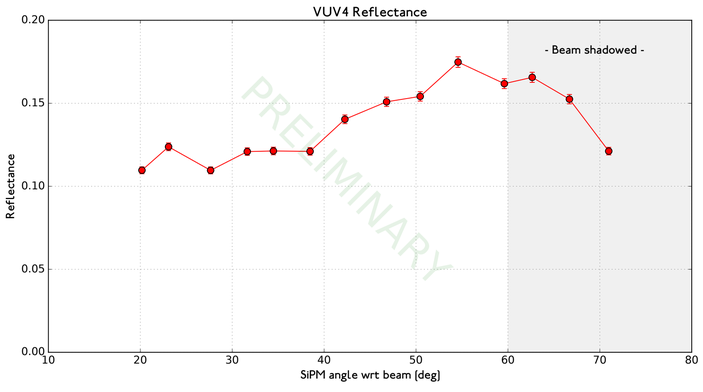
- Depends on PDE and photon transport efficiency
- Example performance in the case of PTE = 0.2

VUV reflectance

- Knowing VUV reflectance of TPC surfaces important for photo collection efficiency
- Measured in collaboration with the *Institut für Kernphysik*, University of Münster



- Measurements accomplished in LXe at -90°C and for 178 nm photons
- Reflectance calculated as ratio between reflectance and zero-reference intensity



PM2018 - 14th Pisa Meeting on Advanced Detectors
27 May to 02 June 2018 - La Biodola, Isola d'Elba (Italy)

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