Scintillating active transverse energy filter (aTEF)

A novel detector concept for angular selective background discrimination

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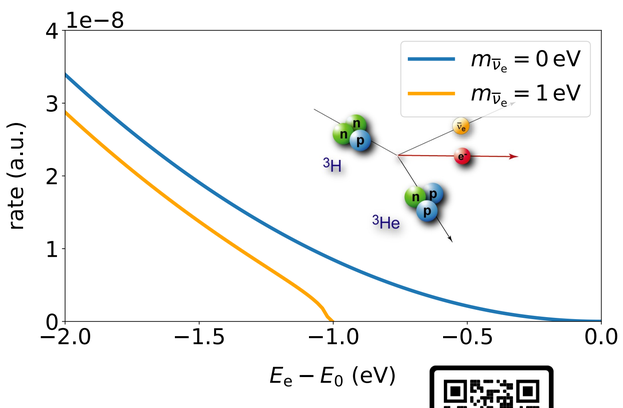
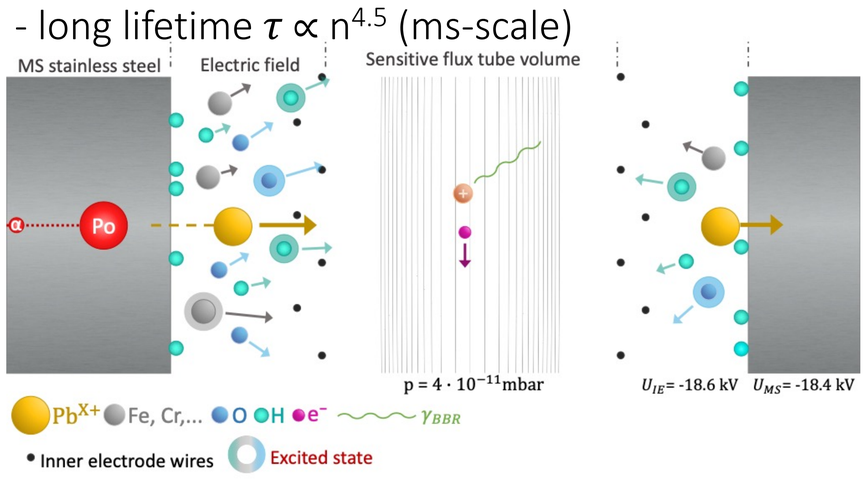
Motivation

KATRIN Goal:
- determination of the neutrino-mass on sub-eV-scale

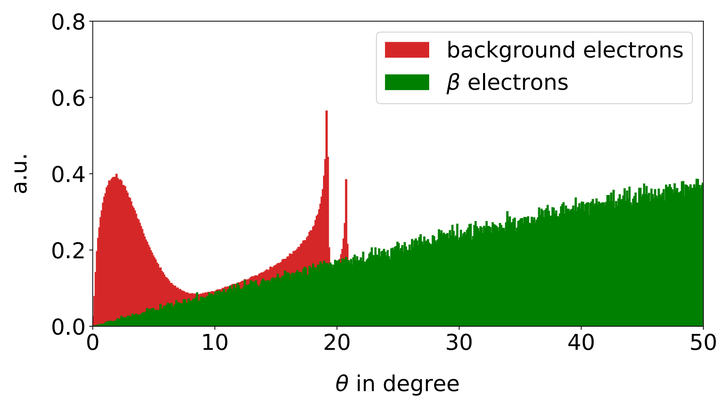


$m_\nu < 0.8\,\mathrm{eV}$

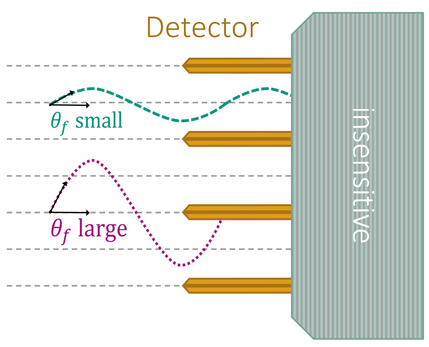
Rydberg Background :
- high n (principle quantum number)
- low initial energy $E_n \propto n^{-2}$ (eV-scale)
- long lifetime $\tau \propto n^{4.5}$ (ms-scale)



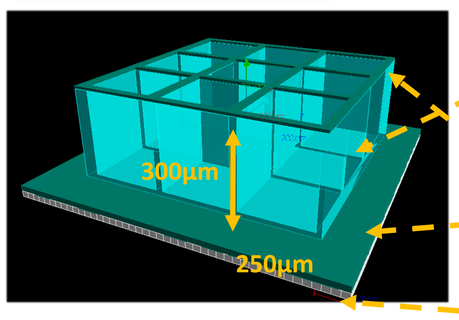
Angular Distribution at Detector:
- electrons are accelerated towards detector
- background has smaller angle than signal



Scint-aTEF principle



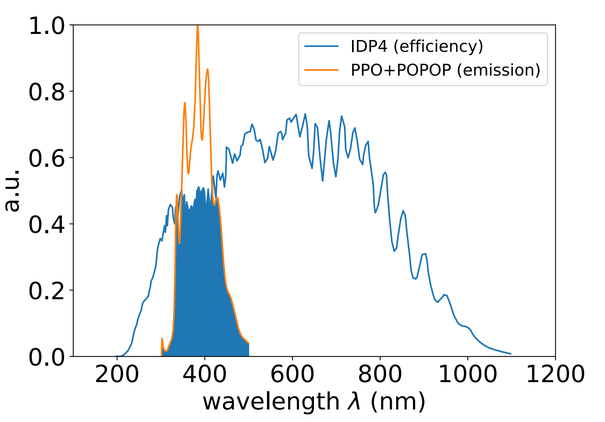
3x3 Cells Example:



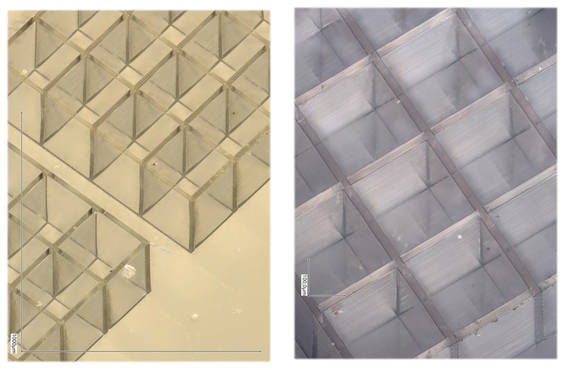
1) Scintillator
- cell dimensions 250 µm x 300 µm
- wall thickness 25 µm

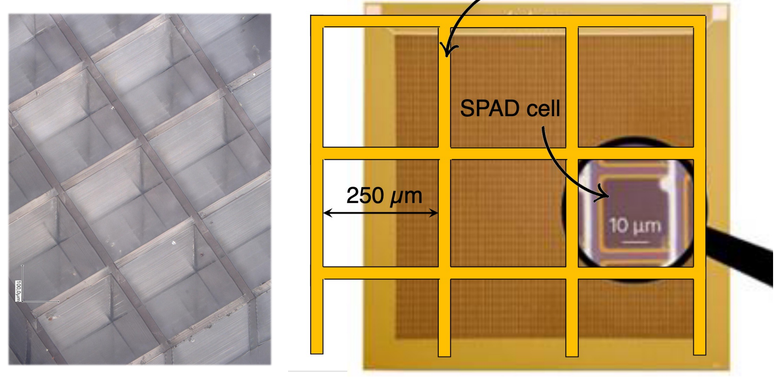
2) non-scintillating blocking layers (~10 µm)

3) SPAD-Array



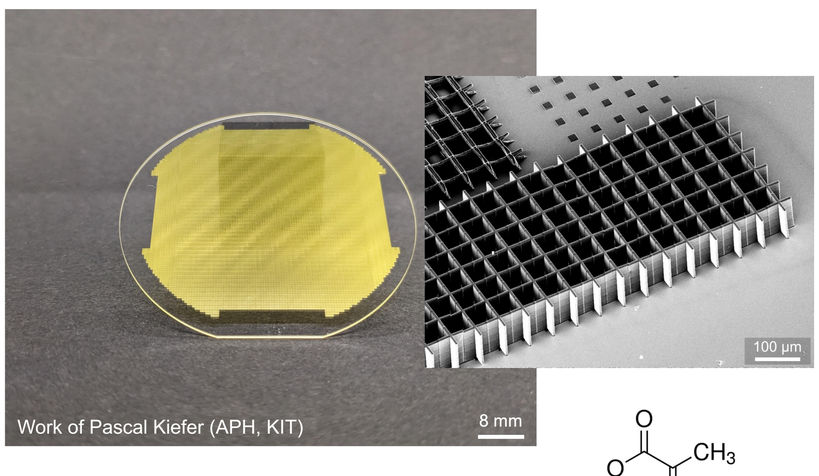
Production via 3D-Printing:
- 2-photon-absorption lithography
- resolution up to the nanoscale
- multi-focus print (large arrays)

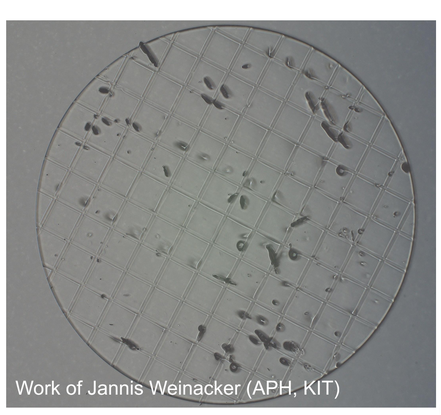


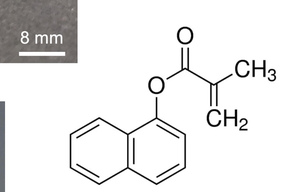


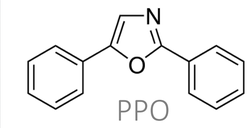
Single-Photon-Avalanche-Diode:
- fast, single photon read out
- spatial information of signal
- optimized quantum efficiency

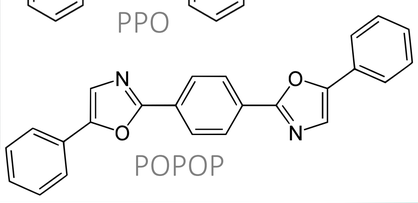
Prototype Development





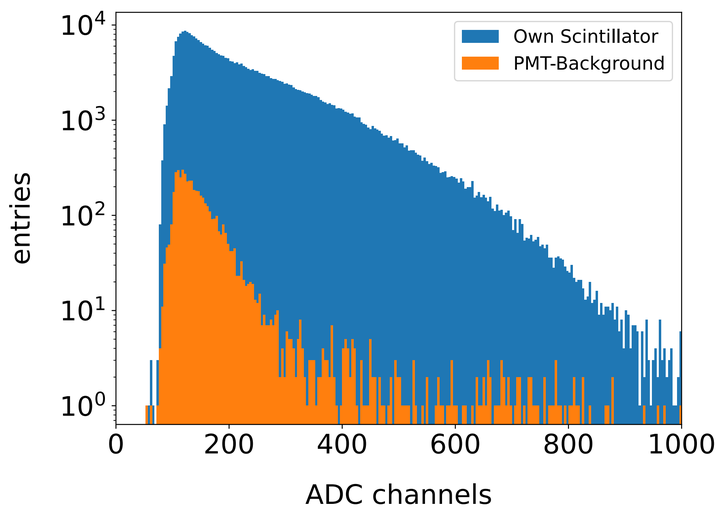




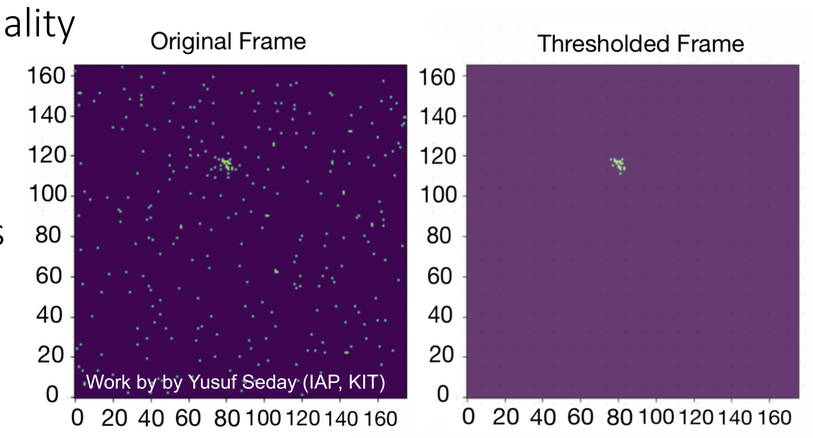


3D-printed Scintillator:
- based on aromatic methacrylates
- 2-stage wavelength shifting
- collaboration with Institute for Applied Physics @KIT (Prof. Wegener)
- challenges: e.g. solubility of POPOP

Characterization with PMT:
- ^{83m}Kr-Source with E_e in keV-range
- optimization of scintillator recipe
- check influence of e.g. surface quality and radiation damages



Single-Event-Resolution:
- read-out of single electron events
- SPAD + Scintillator + ^{83m}Kr-Source
- use topological information to reconstruct the event



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