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Thermal neutron detection based on resistive gaseous devices

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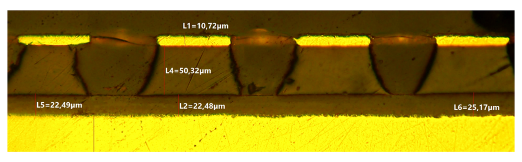
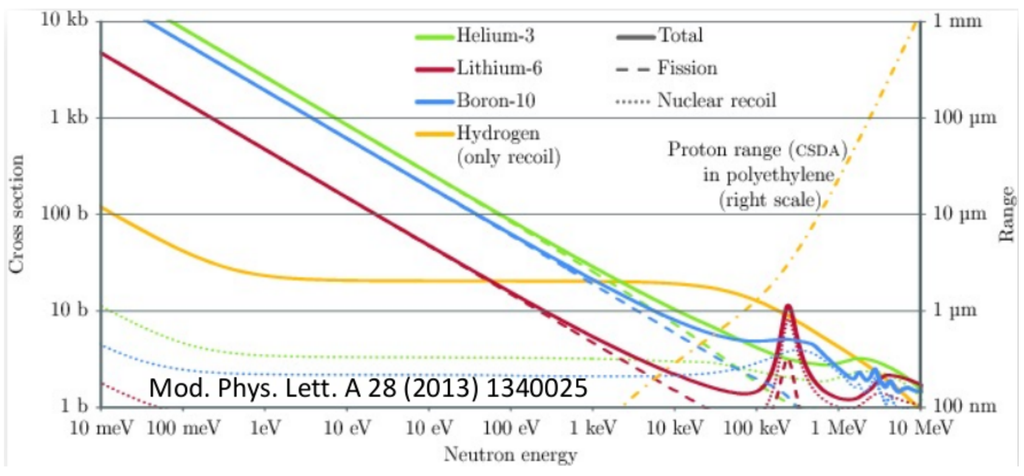


The goal of the **uRANIA-V** project is the development of **thermal neutron detectors** using **$^{10}B_4C$** converters and two gaseous detectors: the **μ-RWELL** and the **sRPC**.

Thermal neutron detection and converter material

- Probing heavy structure in motion
- Radioactive waste monitoring
- Radiaton Portal Monitor (homeland security)
- Neutron diffraction imaging



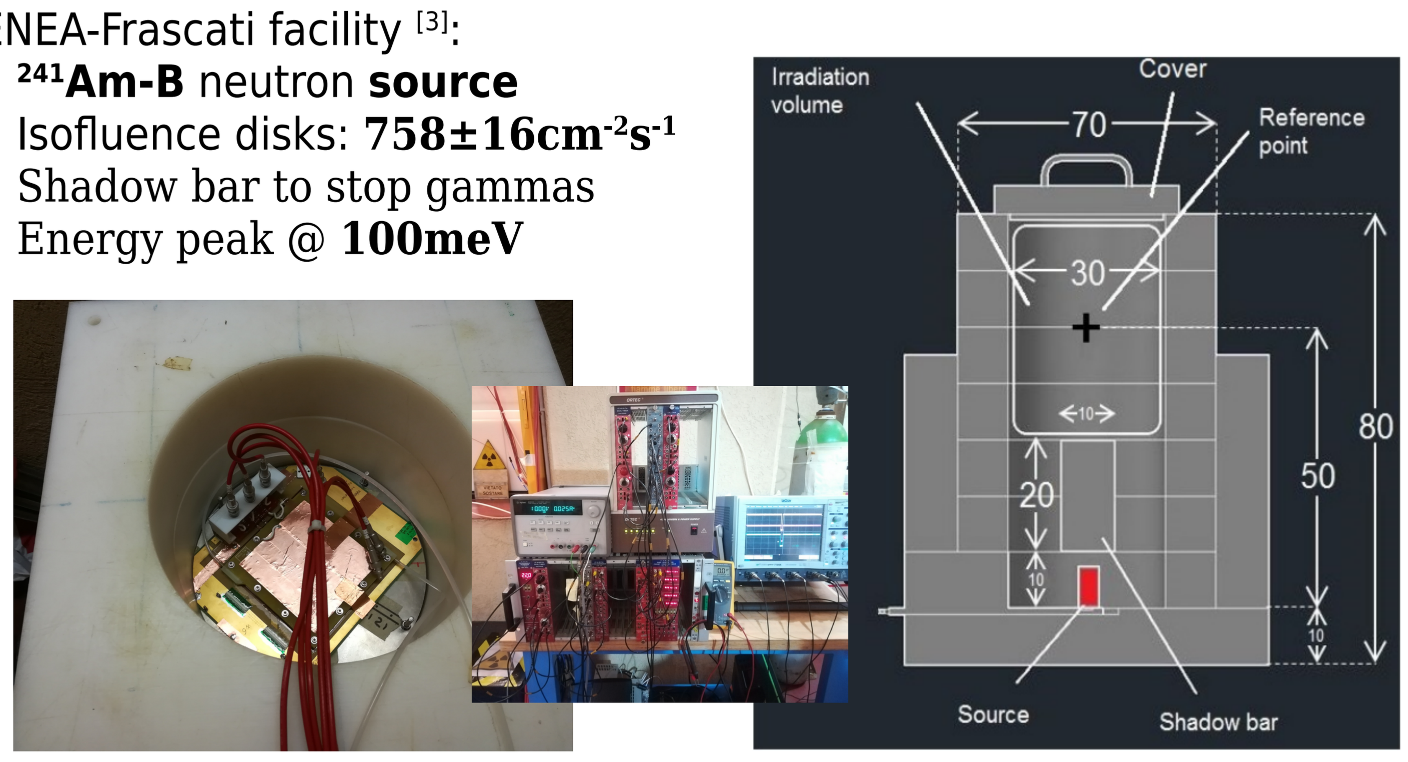
Thermal neutron detection relies on the neutron capture and thus conversion to ionizing particle:
^3He shortage → **^{10}B** alternative: **$^{10}B_4C$ converter.**

Advantages of $^{10}B_4C$

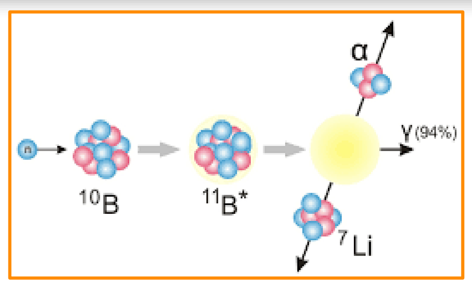
- Chemically stable
- Mechanically robust
- Good adherence on substrates
- Uniform sputtering thickness over large surfaces
- Deposition based on industrial technology

HOTNES – Homogeneous Thermal Neutron Source

ENEA-Frascati facility [3]:
- **^{241}Am-B** neutron **source**
- Isofluence disks: **$758\pm16 cm^{-2}s^{-1}$**
- Shadow bar to stop gammas
- Energy peak @ **100meV**

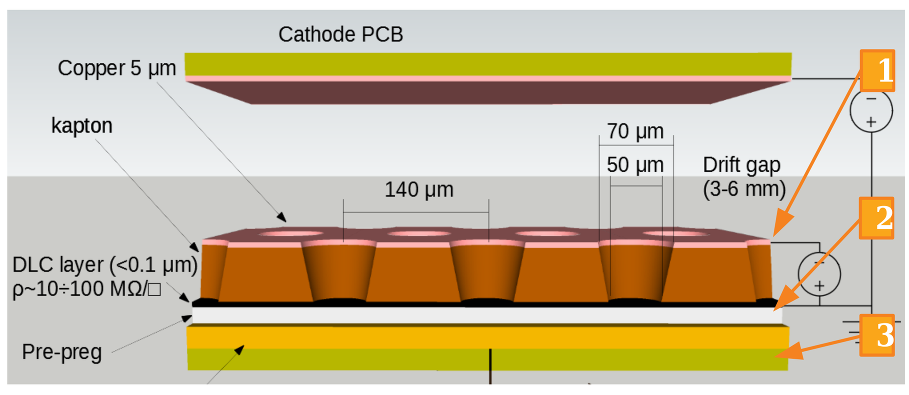


$$n+{}^{10}_{5}B \begin{cases} {}^{7}_{3}Li(1.02MeV)+\alpha(1.78MeV) & 6\% \\ {}^{7}_{3}Li(0.84MeV)+\alpha(1.47MeV)+\gamma(0.48MeV) & 94\% \end{cases}$$

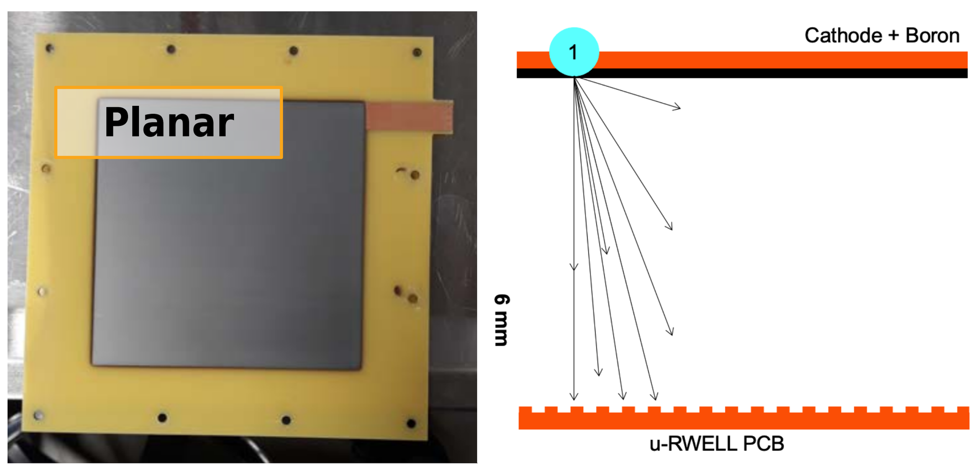


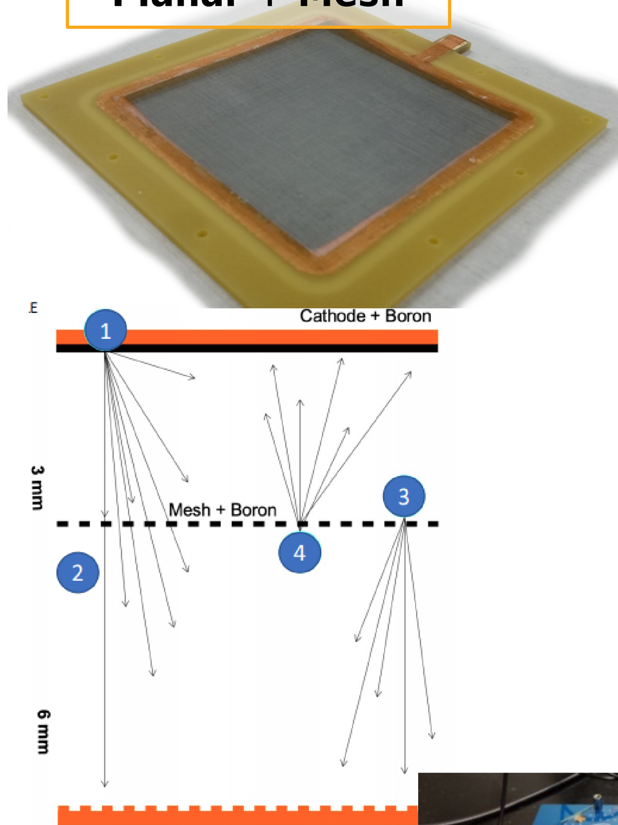
The μ-RWELL – three converter geometries

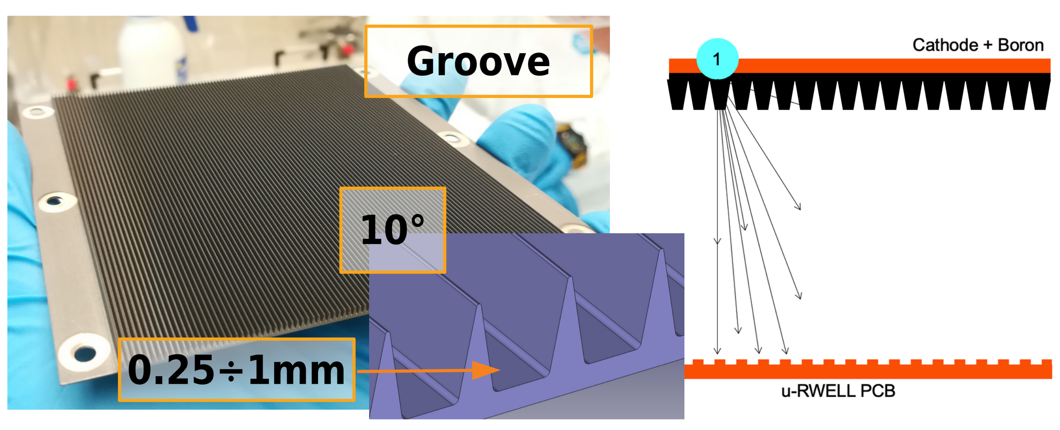
The **μ-RWELL** is a single amplification stage **resistive MPGD**[1]. The cathode surface, facing the gas gap, is **sputtered with $^{10}B_4C$** and is used as a **neutron converter.**

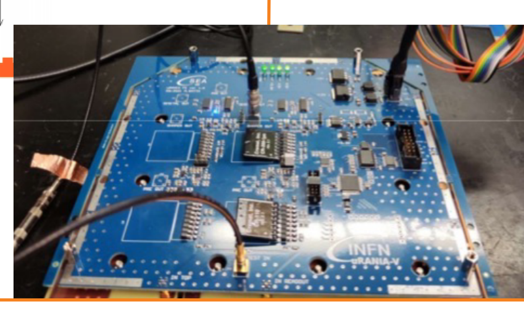


1. A **WELL** patterned kapton foil as **amplification stage**
2. A **resistive layer of DLC** w/ ρ_S~80 MΩ/□
3. A standard readout PCB



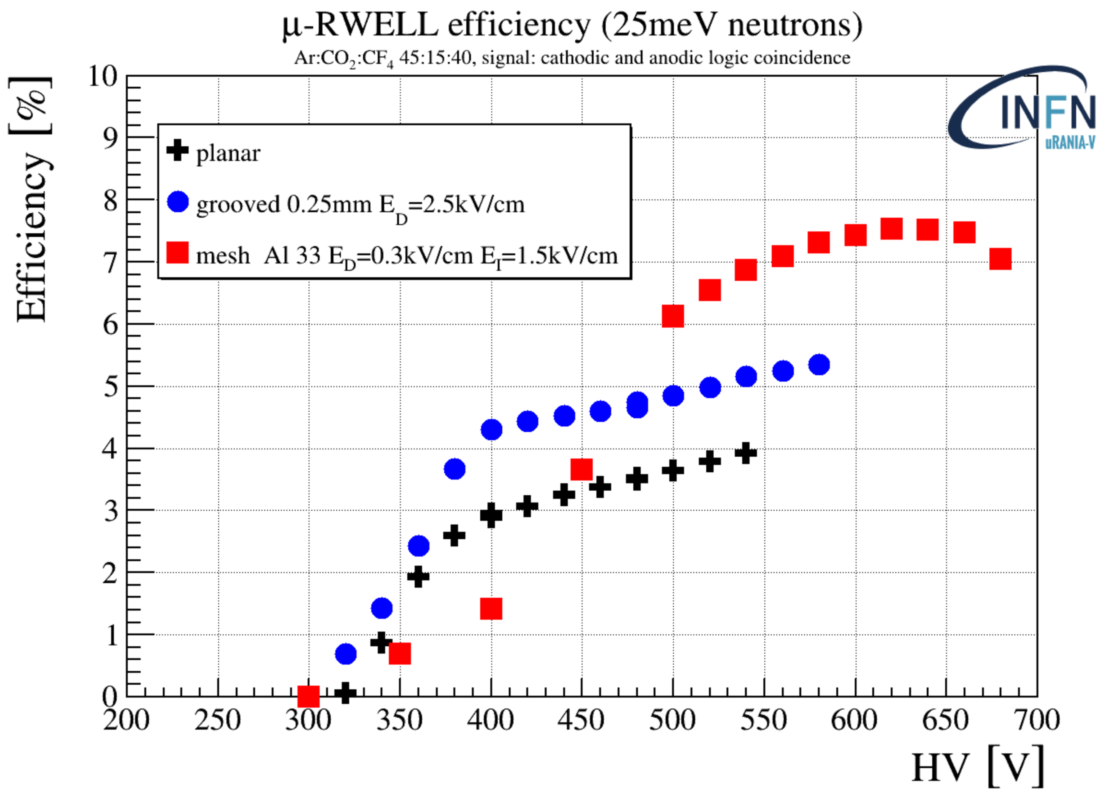






Custom FEE by LNF electronic pool (CR-110 & CR-200)
Gain ≈ 2mV/fC – Shaping 1μs

μ-RWELL efficiency for different converters

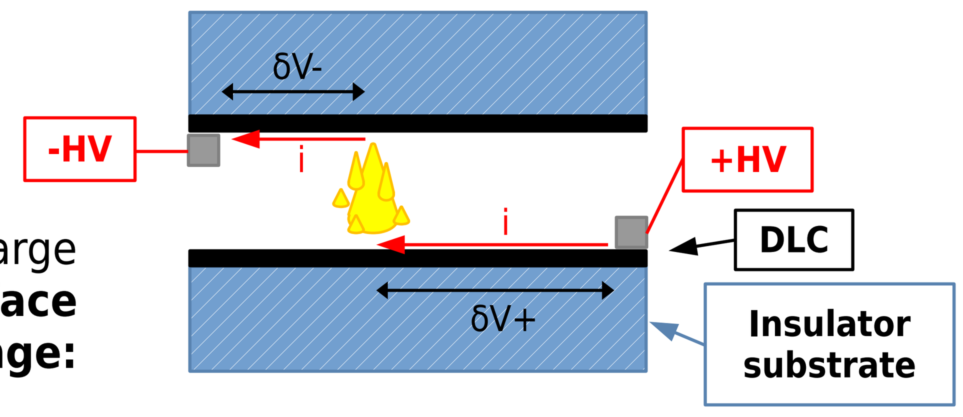


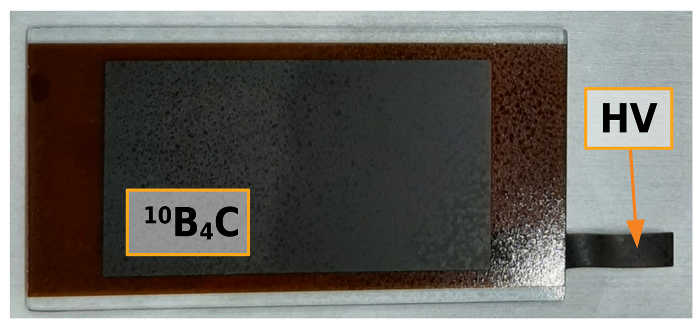
PLANAR: reference cathode
MESH: higher working point → e⁻ have to pass the mesh
GROOVE: slightly higher plateau than planar → e⁻ extraction from grooves

A stacking of μ-RWELLs → efficiency up to 15%

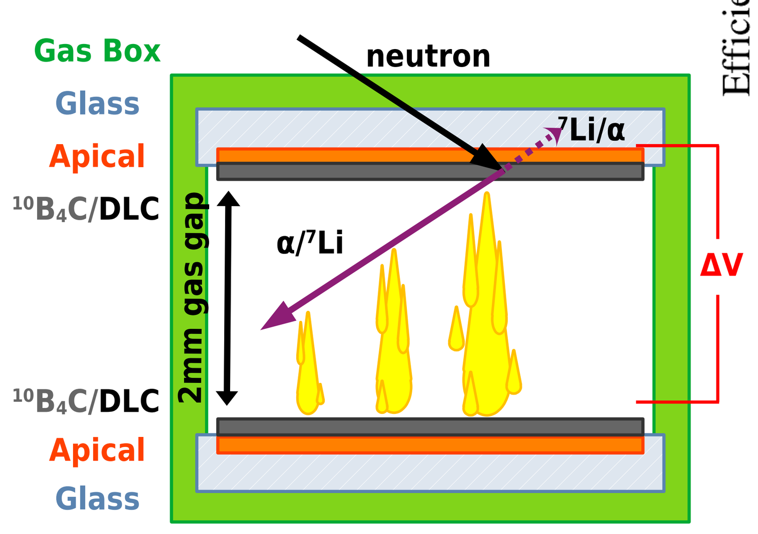
The sRPC – a new RPC paradigm

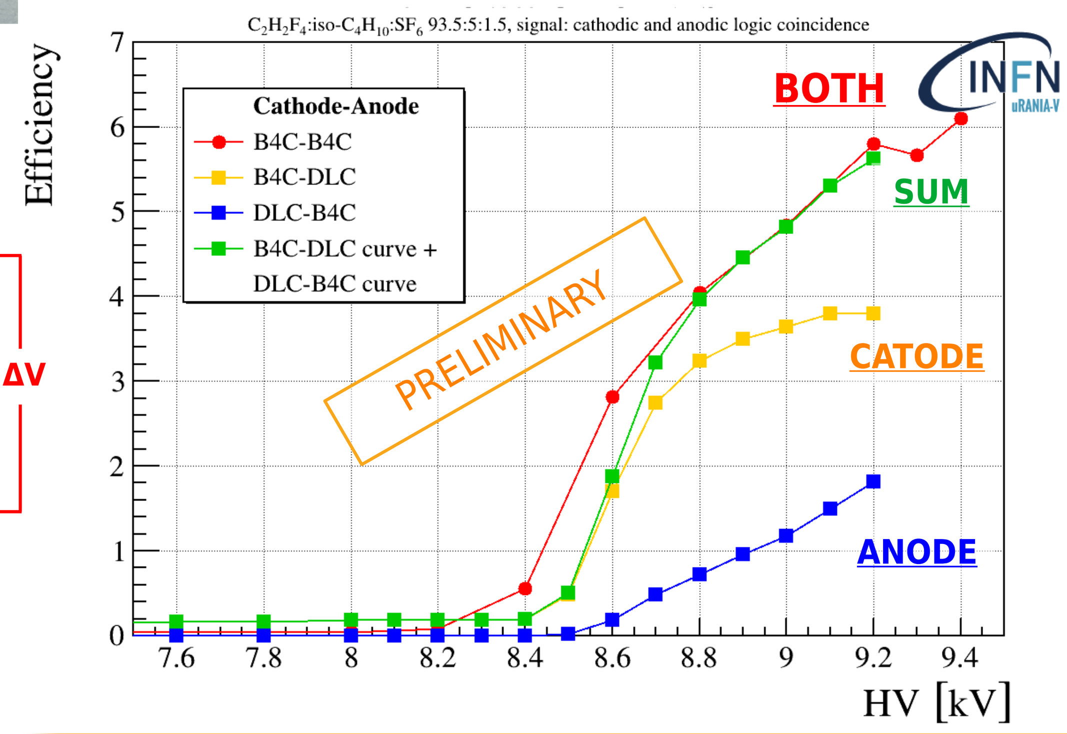
The **sRPC**[2] DLC electrodes are manufactured with sputtering techniques on flexible supports. The technology allows to realize large electrodes with a DLC **surface resistivity** in a very **wide range: 10 MΩ/□ ÷ 10 GΩ/□**.





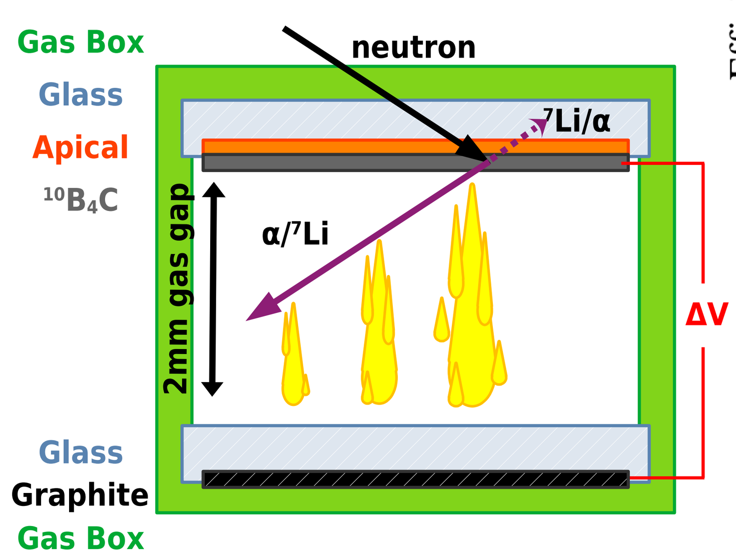
It is possible to **switch one or both** DLC electrodes with **$^{10}B_4C$**: it will act both as converter surface and high voltage electrode.

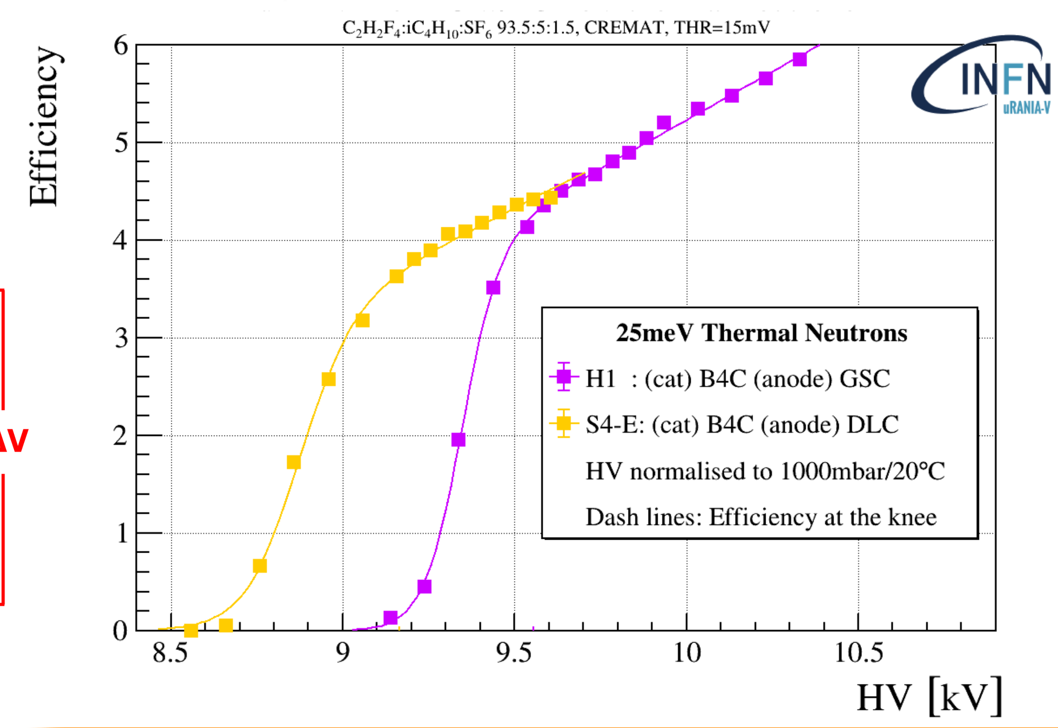




$\alpha/^7Li$ **mean path** < **2mm** ⇒ CAT and AN have different behaviors
- **$^{10}B_4C$ CAT** – **DLC AN** : the expected 4% plateau was reached
- **DLC CAT** – **$^{10}B_4C$ AN** : efficiency depends on the HV
- **$^{10}B_4C$ CAT** – **$^{10}B_4C$ AN** : the $^{10}B_4C$—$^{10}B_4C$ performs as the **SUM**

To reduce detector cost → hybrid layout:
$^{10}B_4C$ CAT and **glass AN**: 4% plateau as **$^{10}B_4C$ CAT** – **DLC AN**





[1] G. Bencivenni et al., *The micro-Resistive WELL detector: a compact spark-protected single amplification-stage MPGD*, 2015 JINST 10 P02008
[2] M. Giovannetti et al., *The surface Resistive Plate Counter (sRPC): an RPC based on MPGD technology*, 2023 JINST 18 C06026
[3] A. Sperduti et al., *Results of the first user program on the Homogeneous Thermal Neutron Source (ENEA/INFN)*, 2017 JINST 12 P12029

More on μ-RWELL?
→ G. Bencivenni's talk – *The μ-RWELL for future HEP challenges*
→ G. Morello's poster – *The μ-RWELL technology for tracking apparatus in HEP*