MPGD Applications: µRANIA

Neutrons? Why?

- Probing the structure and motion
- High penetration and precision
- High sensitivity and selectivity
- A unique probe for magnetism
- A probe of fundamental properties

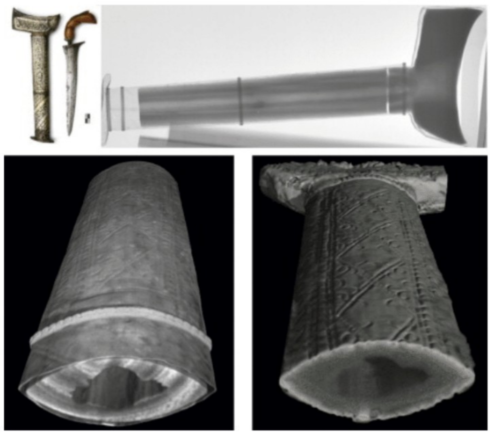


Figure 1: Non-destructive imaging of an Indonesian dagger sheath, illustrating how neutrons mitigate the obscuring effects of the outer metal cover on images of the inner wooden parts. Top left: A photograph of the dagger and the sheath, which has an outer metal cover (containing silver) and an inner wooden structure. Top right: A neutron transmission (radiography) image. Bottom left and right: 3D renderings of neutron and X-ray tomography data, respectively. Courtesy of E.H. Lehmann [1].

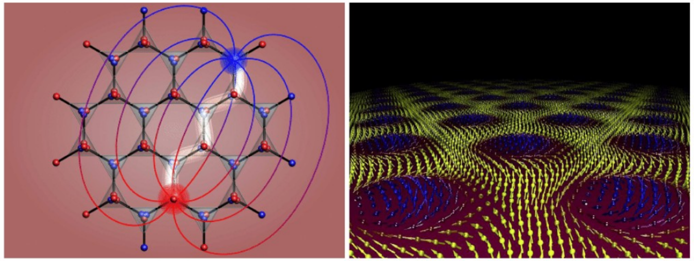
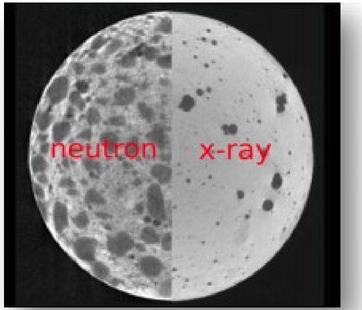


Figure 2: Dirac strings and a Skyrmion lattice. Left: A pair of separated monopoles, in red and blue, with a chain of inverted dipoles between them. Dirac strings are highlighted in white with the associated magnetic field lines [2]. Right: Magnetic vortex spin ordering in a Skyrmion lattice as first revealed by neutron scattering [3].

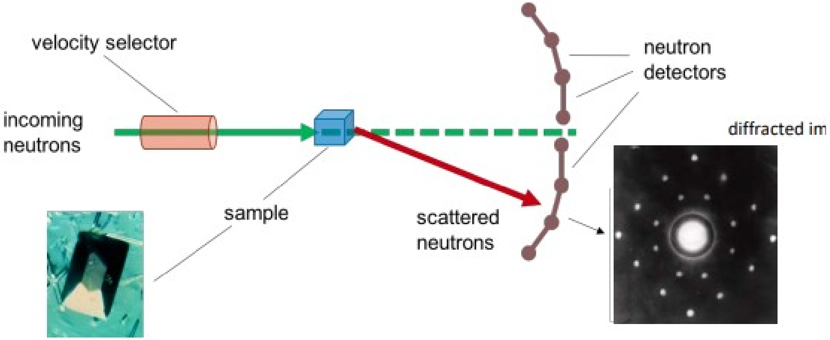
ESS Technical Design Report S. Peggs (ESS, Lund)(ed.), 2013

Some applications close to µRANIA project

- Complementary to X-ray imaging



- Neutron diffraction imaging



- Radioactive waste monitoring (PuO_2 or PuF_4)

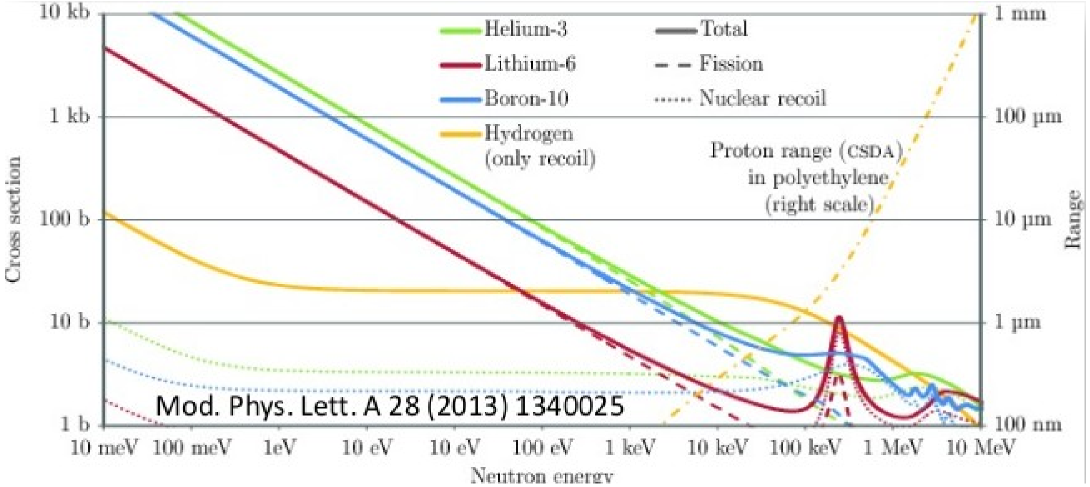
- Radiation Portal Monitor (RPM) for homeland security

Neutron detection

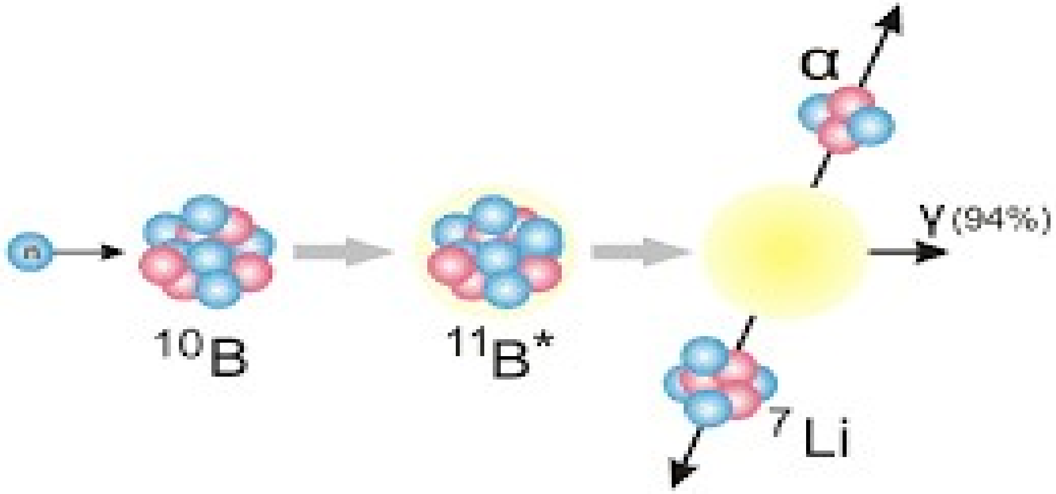
In literature, neutron detection is categorized according to the nuclear processes, mainly neutron capture and elastic scattering.

The neutron detection happens by means of the neutron caption reactions into electrical signals through particles and energy released. Nuclides such as 3He, 6Li, 10B and other heaviers like 235U have a high neutron capture cross section and a larger probability of absorbing a neutron.

Reaction	Q-value [MeV]	Cross section for thermal neutrons [barns]
$^{10}B + n \rightarrow {}^{7}Li + \alpha$	2.31	3840
$^{6}Li + n \rightarrow {}^{3}H + \alpha$	4.78	940
$^{3}He + n + {}^{3}H + p$	0.754	5330
$^{235}U + n + X + Y$	~200	575



Boron converter

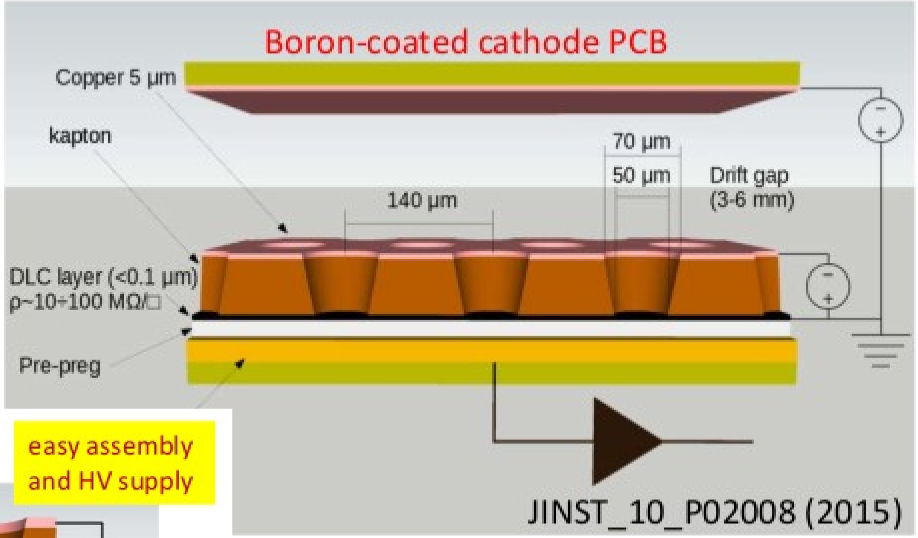


$$n + {}^{10}B \rightarrow {}^{11}B^* \rightarrow \alpha + {}^{7}Li$$

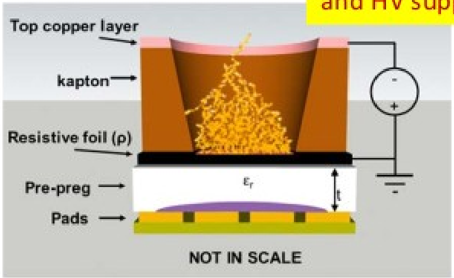
µRWELL gas detector

- Development of an innovative neutron detector based on micro-Resistive WELL technology: a compact, spark-protected, single-amplification stage MPGD

- Single amplification stage resistive MPGD composed of
  - µ-RWELL_PCB
  - drift/cathode PCB defining the gas gap
- µ-RWELL_PCB
  - ampl.-stage
  - res.-layer
  - r/out PCB (with suitable segmentation)
- Large area & flexible geometry



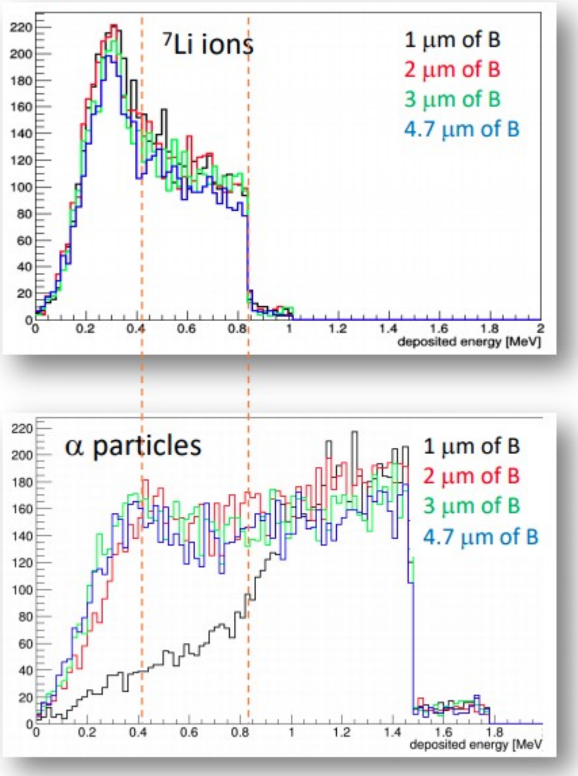
easy assembly and HV supply



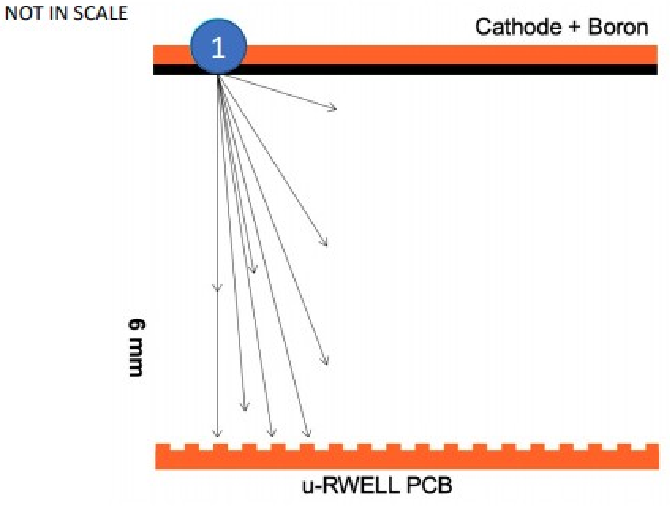
Neutron converter simulation

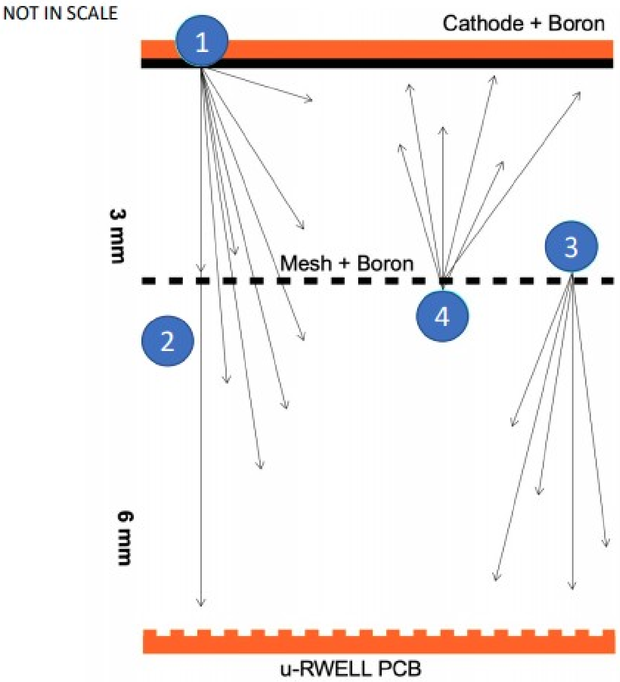
- Simulation is used to optimize the detector and to extract the detection efficiency from the current measurement
- Gas mixture ionizing energy ~ 31.5 eV
- Particles range < 6 mm of gas
  - all the energy released in the gas
  - ~10^4 number of primaries
- Neutron source energy distribution and divergence considered in the simulation

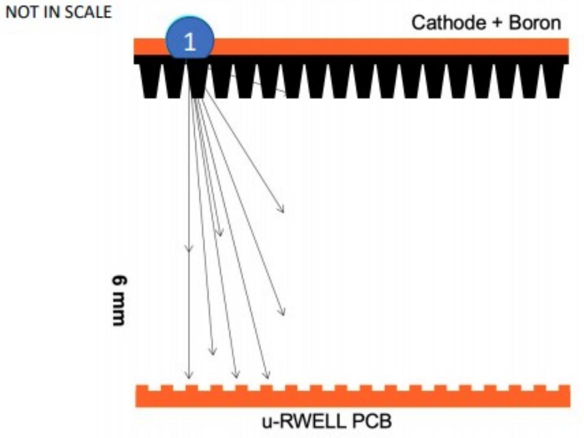
Energy release for different Boron thickness



Design under test







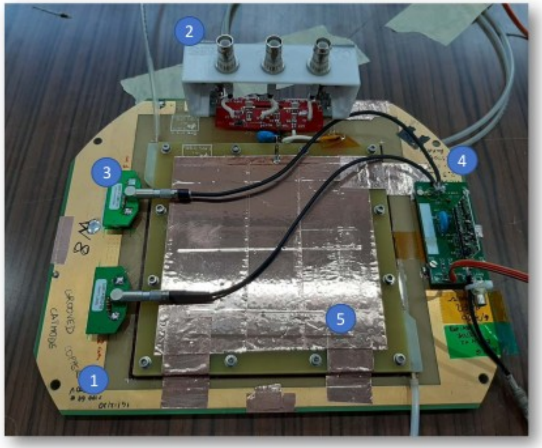
Neutron flux and efficiency measurements

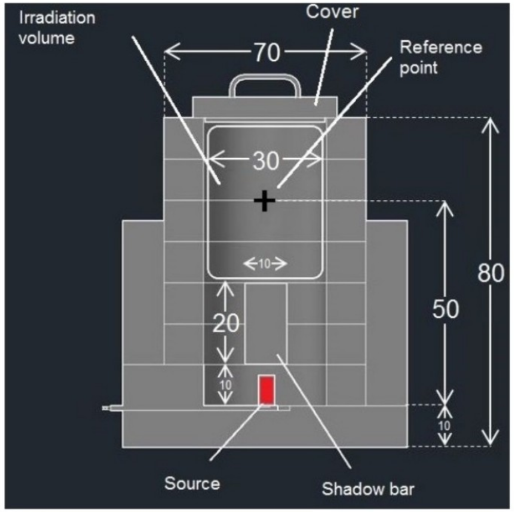
CURRENT MODE

$$\epsilon = \frac{i}{\Phi \cdot S \cdot e \cdot G \cdot < N >}$$

COUNTING MODE

$$\epsilon = \frac{N_{DET}}{\Phi \cdot S \cdot \Delta T}$$





- N_{DET} = neutron detected
- i = current ($C\ s^{-1}$)
- Φ = neutron flux (758 $cm^{-2}\ s^{-1}$)
- ε = efficiency = #α seen/#neutrons
- N_{ION} = # ele from ionization = primaries & secondaries = E_{DEP}/E_{ION}
- G = gain
- S = surface 10 x 10 cm^2

Outlook and future plans

- The milestones of the project will drive the R&D to the deveopment of a large area prototype for Radio-Protection Monitors

- Ingeneering of the project with the finalization of the detector and the electronic design

- Collateral activities from the neutron detection esperience (i.e. a sputtering facility for boron and DLC to create a production center in Europe between CERN and INFN)