



Investigation of triple-discriminating plastic scintillators for the detection of SNM in active measurements by photofission at 7 MeV



CEA/DRT/List/DM2I/SCI/LCAE – Aly ELAYEB

ENTRANCE project:

Photofission technique can be applied to detect Special Nuclear Material (SNM) hidden inside cargo containers, which can be used to make nuclear weapons or “dirty bombs”. This technique relies on detecting prompt and delayed neutrons and gamma rays emitted by the photofission reaction for which the energy threshold is around 6 MeV for plutonium and uranium isotopes. For the ENTRANCE project, the technique is investigated at 7 MeV, near the energy threshold, for compact linacs embedded in X-Ray mobile scanners.

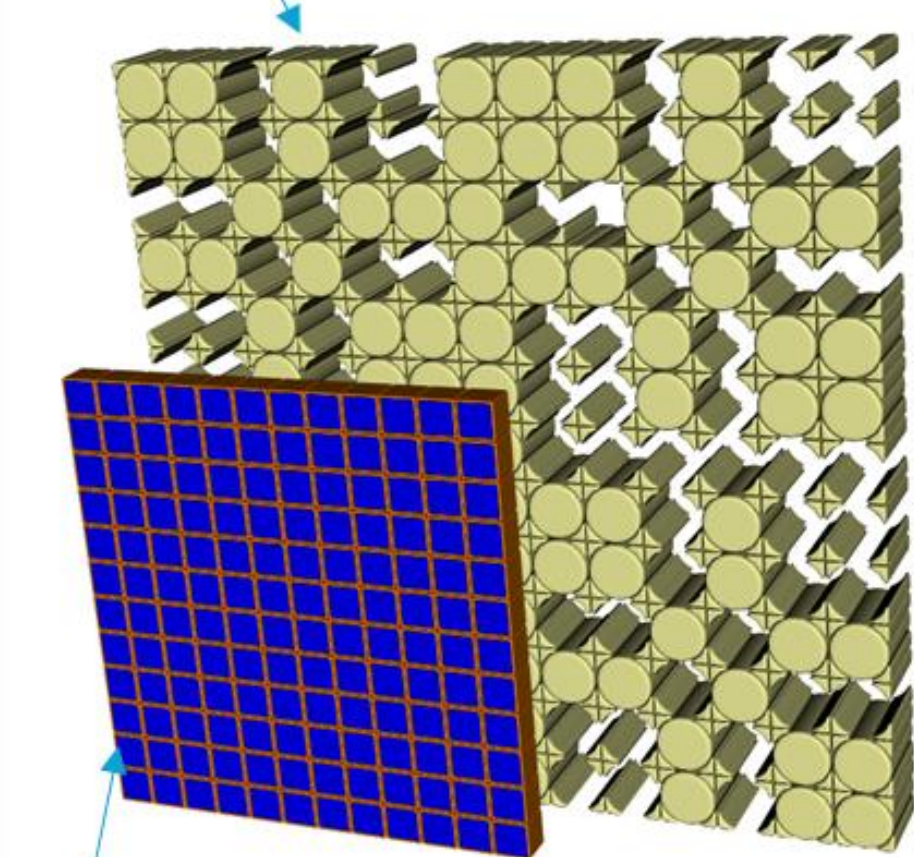
Problem description:

- Prompt neutrons make up for 97% of the neutron signature but signal is drowned in high gamma and photoneutron noise coming from the linac during a few ms
- Traditional technique relies on measuring only delayed neutron after a given detector blinding time between the linac pulses (interpulse measurements)
- ^3He proportional counters are used to make up for the low amount of signal

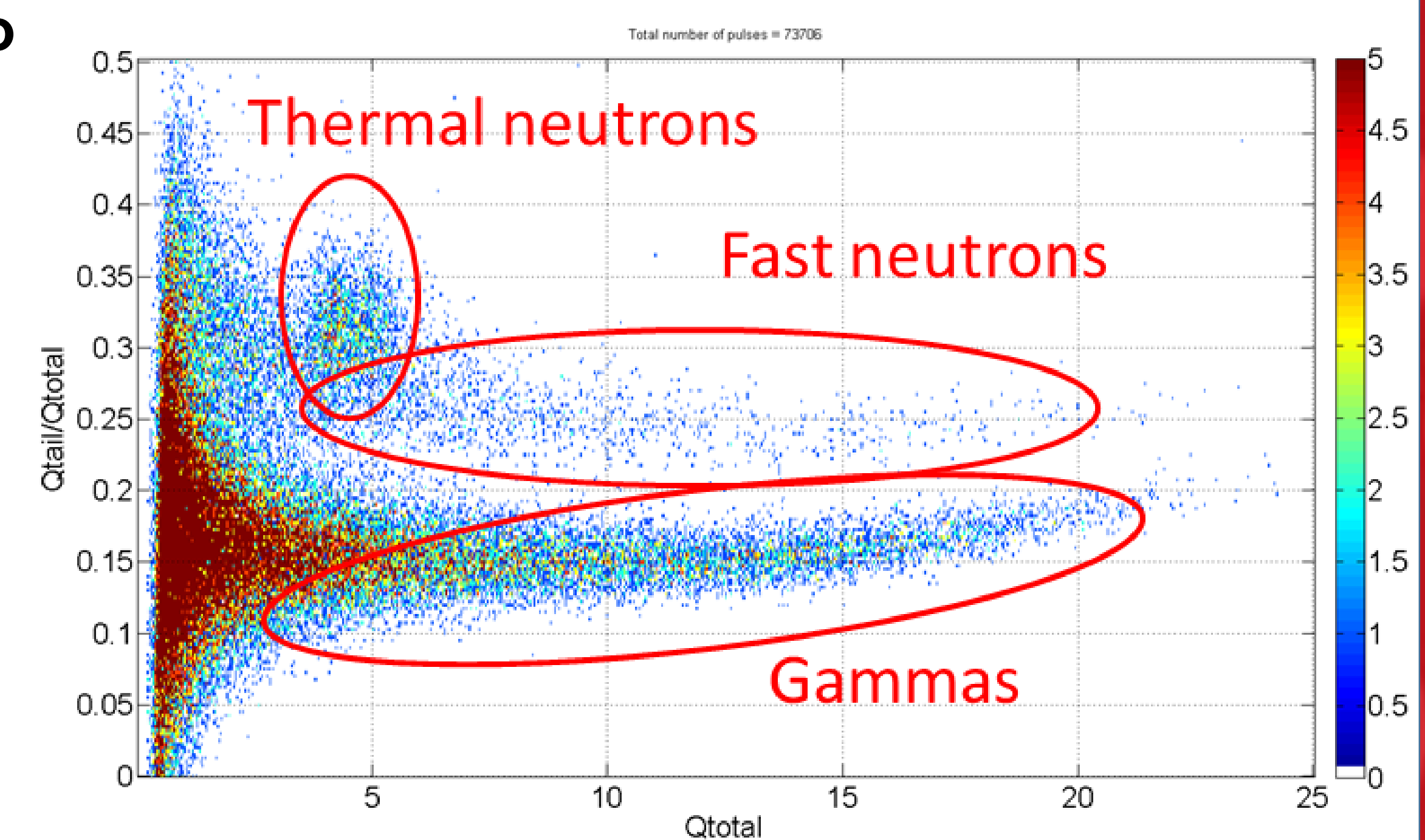
Approach:

- Operating at 7 MeV with shielding improves significantly the signal to noise ratio
- Rough neutron imager: 24x24 pixel array of plastic scintillator with MURA mask
- Mask/antimask coded aperture procedure allows spatial noise rejection of up to a factor 100
- Using triple discriminating scintillators by PSD for thermal neutrons discrimination in traditional interpulse measurements
- Fast neutron discrimination is used to reconstruct image from prompt neutrons

Coded mask aperture

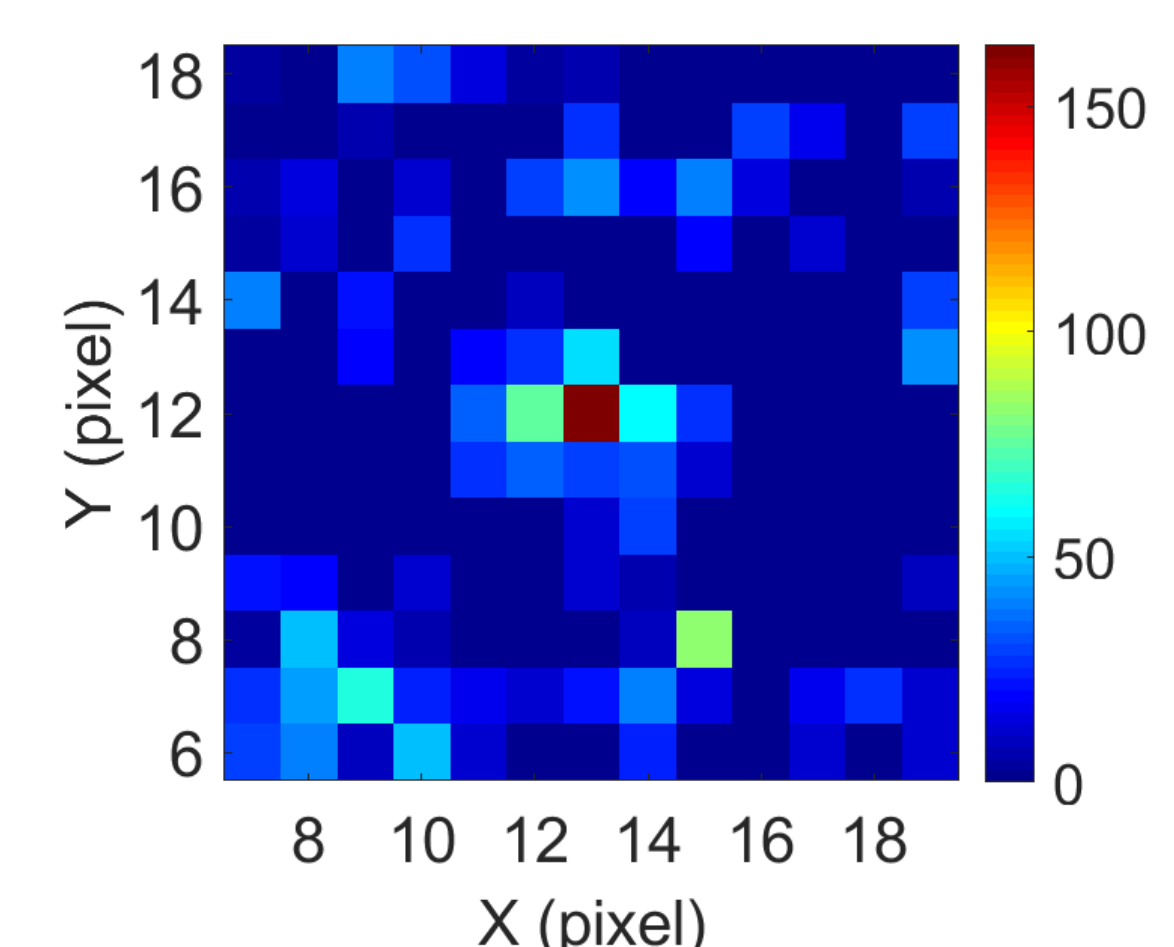
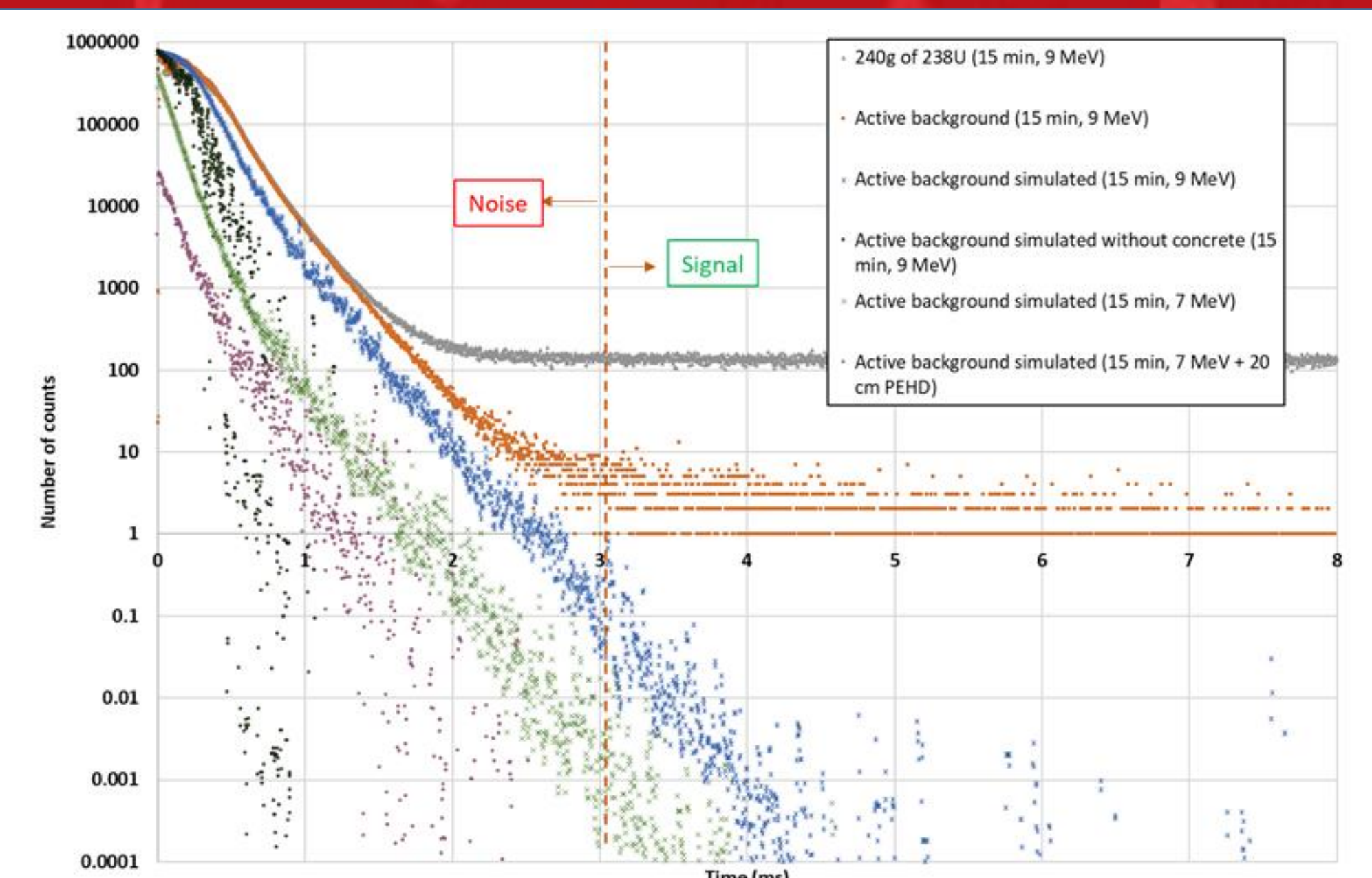
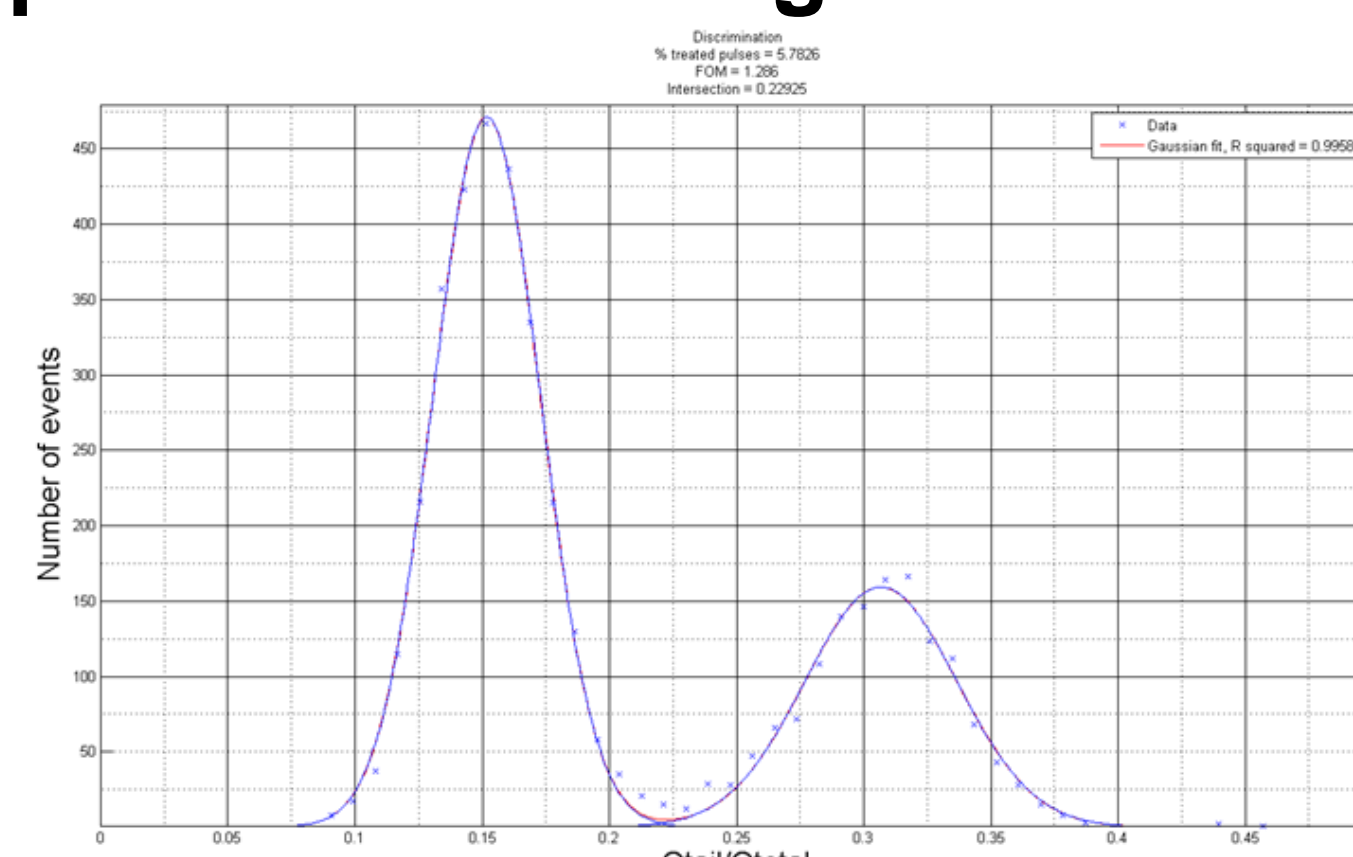
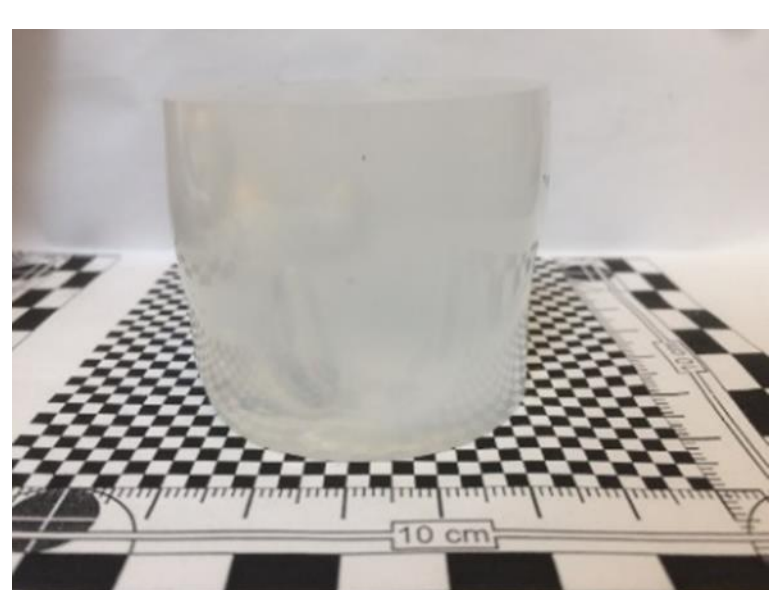


Roughly pixelated plastic scintillator



First results:

- Interpulse measurements sensitivity loss of a factor of 230 compared to a 9 MeV operated linac
- Reduction of the photoneutron noise by a factor of 30 with 20cm PEHD shielding around the linac
- Reconstruction of the localization of the source with a photoneutron noise 45 times higher than the prompt neutron signal thanks to the mask/antimask procedure
- Manufacturing and characterization of the triple discriminating scintillator for future field tests



Next steps:

- Further optimization of the neutron and gamma shielding as well as the mask parameters for better sensitivity and noise rejection
- Field tests in the fall of 2022 with a 7 MeV linac in collaboration with Smiths Detection

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