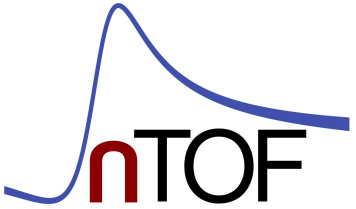
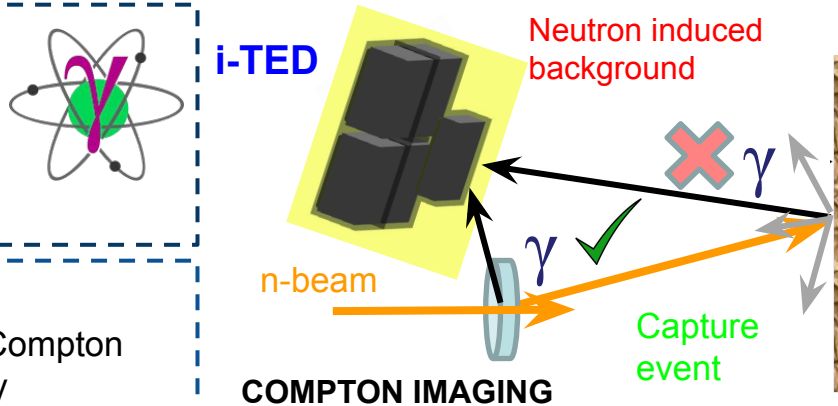
ML and AI in the HYMNS-ERC project

V. Babiano, ***J. Balibrea-Correa,*** *L. Caballero, C. Domingo-Pardo, I. Ladarescu,* ***J. Lerendegui-Marco***



ML and AI in the HYMNS-ERC project

AREA: Experimental nuclear astrophysics (CERN n_TOF)
Gamma group: http://webgamma.ific.uv.es/gamma/es/
HYMNS-ERC Project:
https://hymnserc.ific.uv.es/



COMPTON IMAGING APPLIED TO EXP. NUCL. PHYSICS

PROBLEMS:

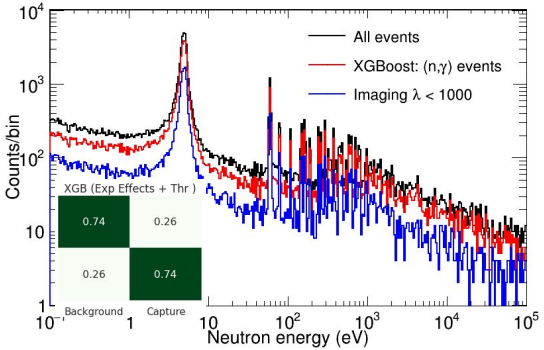
- Background reduction in (n,γ) experiments → Analytical Compton Imaging approaches lead to a drastic drop in the efficiency
- Very large & thick monolythic $LaCl_3$ crystals → Position reconstruction algorithms introduces *pin-cushion* effect.

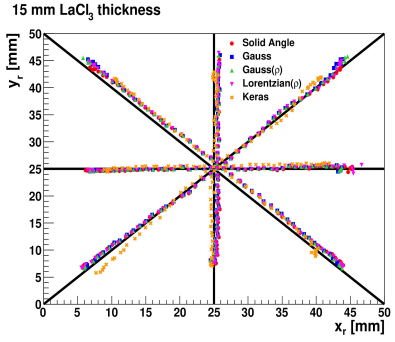
XGBoost or **Keras**: >70% accuracy in the S/B discrimination → x3-4 efficiency enhancement

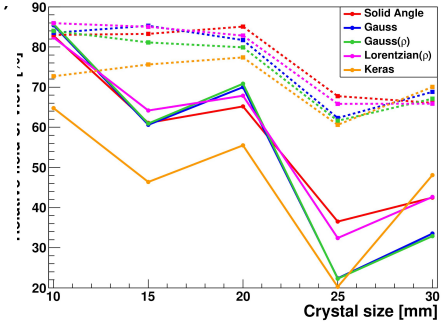
Support Vector Machine algorithm to decompress → Enlarged field of view

ML-AI SOLUTIONS:

- XGB
- Tensolflow + Keras
- SVM
- LNN
- ...





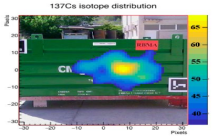


ML and AI in the HYMNS-ERC project

BACKUP

European Research Council
CSIC Consejo Superior de Investigaciones Científicas
Universitat de València
nTOF

HYMNS-ERC Project

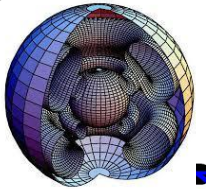


HYMNS

European Research Council

nucleosynthesis & MS evolution

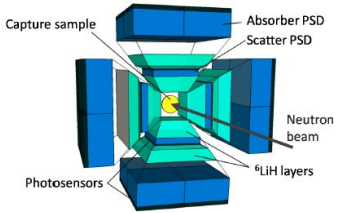
2023



2022

Transfer to society

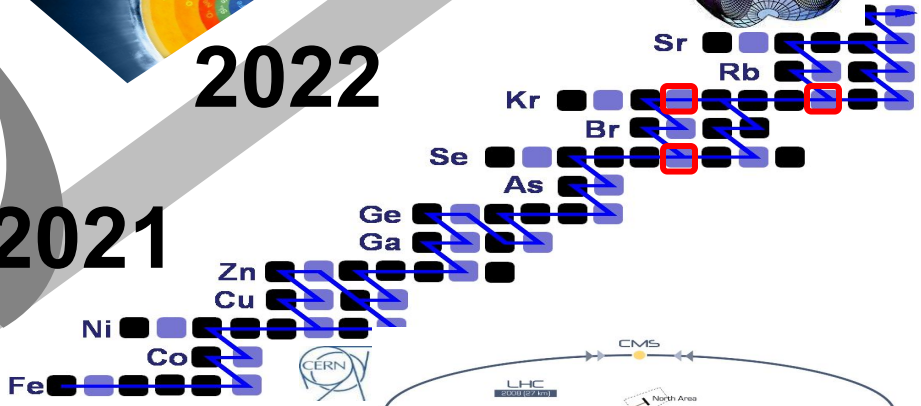
4π Compton imager for **stellar neutron rates**



CNA Centro Nacional de Aceleradores

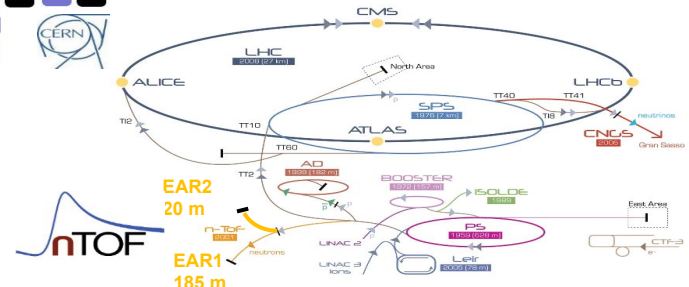
versatile, high efficiency, FoV, **Compton imager**

2021



2020

2019

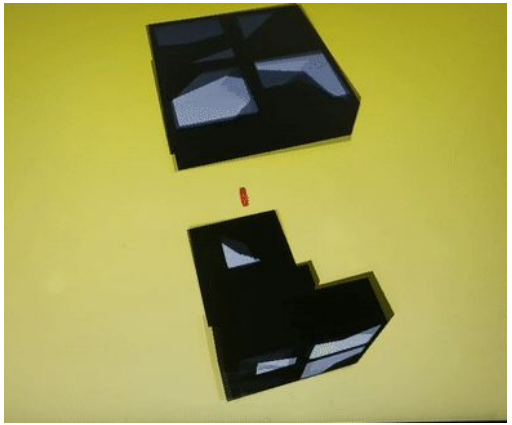


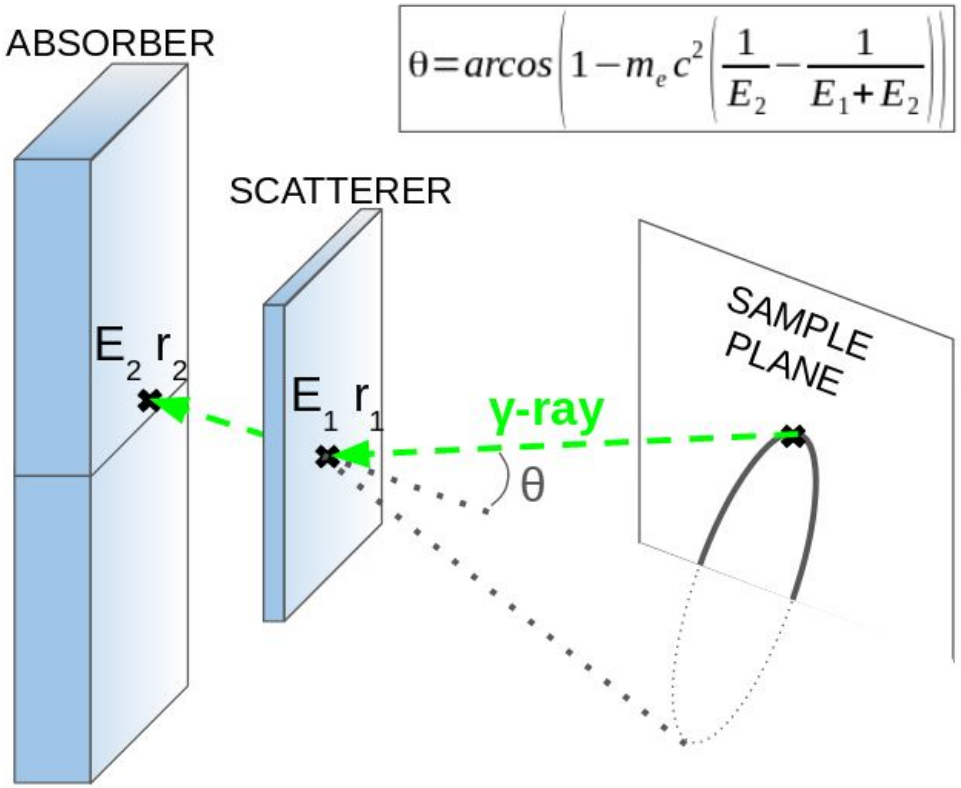
i-TED detector concept

iTED is a compton imager with detection planes:

- Large monolithic $LaCl_3$+SiPM position sensitive detectors working in time-coincidence.
- For each event we retrieve: {E1,r1,E2,r2}
- Background suppression made on compton imagining.

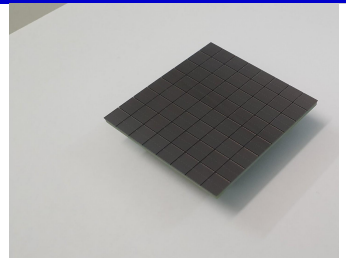
Full array made of four iTED detector modules:

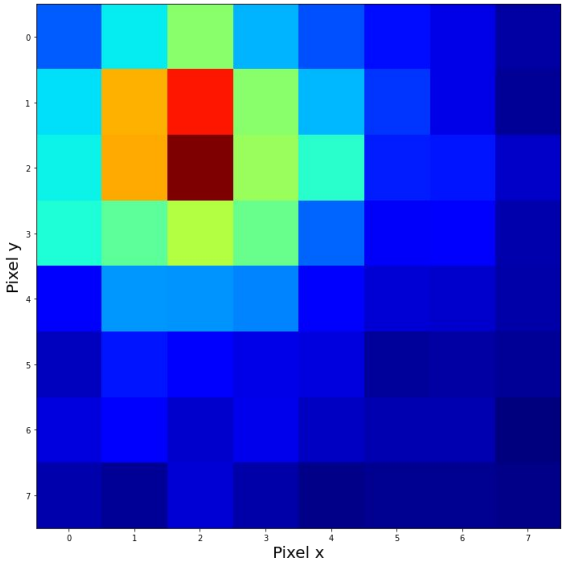




$$\theta = arcos\left(1 - m_e c^2\left(\frac{1}{E_2} - \frac{1}{E_1 + E_2}\right)\right)$$

x-y position reconstruction methodology





(x_r, y_r, z_r)

GPUFIT:
Scientific Reports,
vol. 7, 15722 (2017)

- Li [kernel-14]

Phys. Med. Biol. 55 (2010) 6515-6532

- Gauss [kernel-22]

Phys. Med. Biol. 53 (2008) 1843–1863

- Gauss(ρ) [kernel-23]

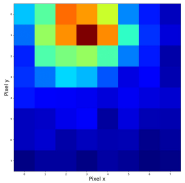
$\rho=Cov(x,y)/\sigma_x\sigma_y$

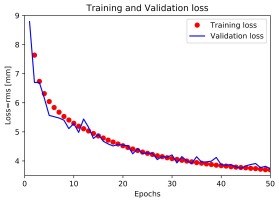
- Cauchy(ρ) [kernel-24]

$\rho=Cov(x,y)/\sigma_x\sigma_y$

Optical Photons simulation:
P. Olleros et al 2018 JINST13 P03014

3D tensorflow models for the individual crystals

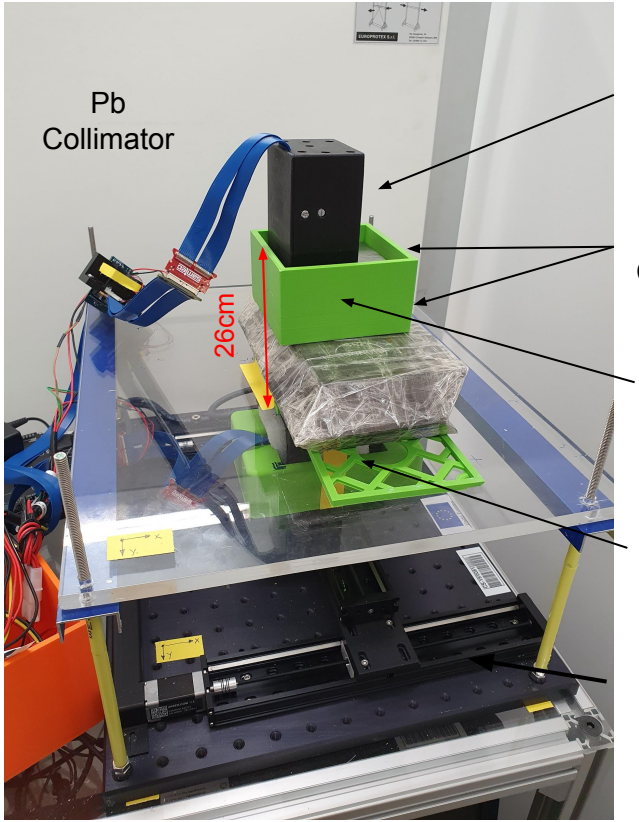




Light map from SiPM for a single event.

ML applied to position reconstruction

Systematic experimental setup for detector characterization



$LaCl_3$ detector

W Collimators

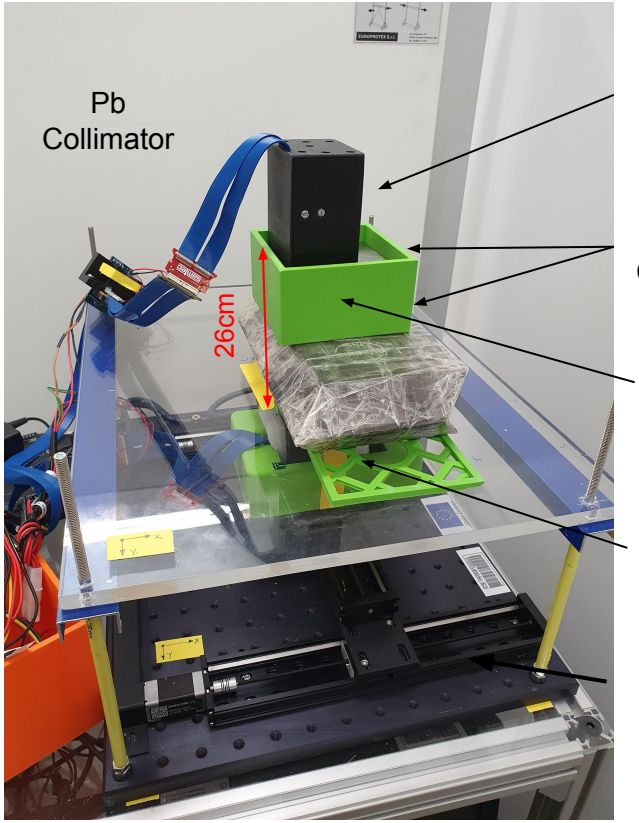
^{22}Na source

$LaCl_3$ detector

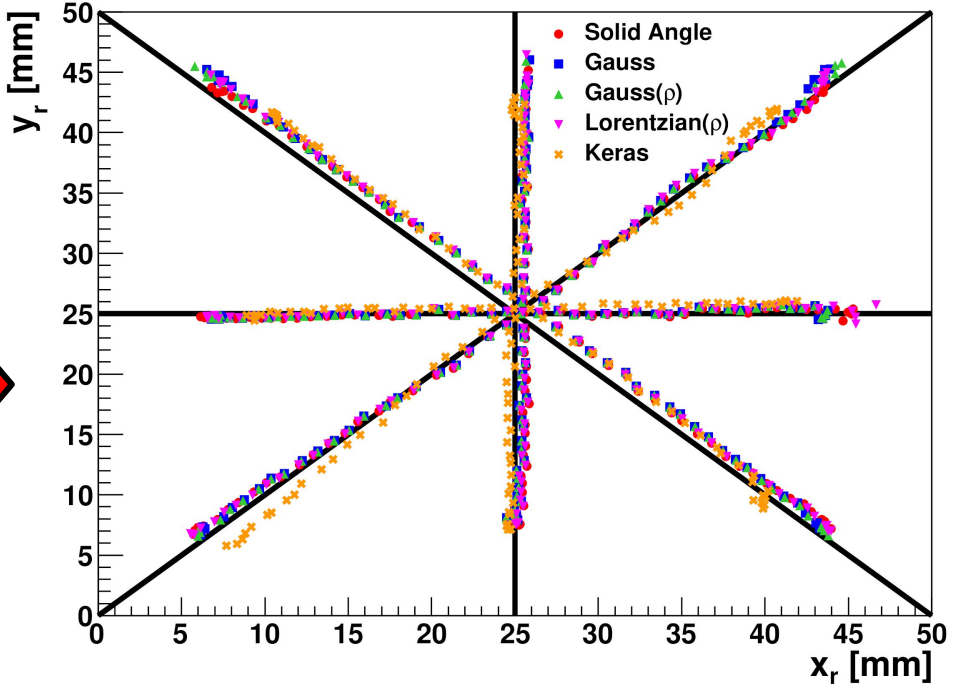
X-Y table

ML applied to position reconstruction

Systematic experimental setup for detector characterization



15 mm $LaCl_3$ thickness



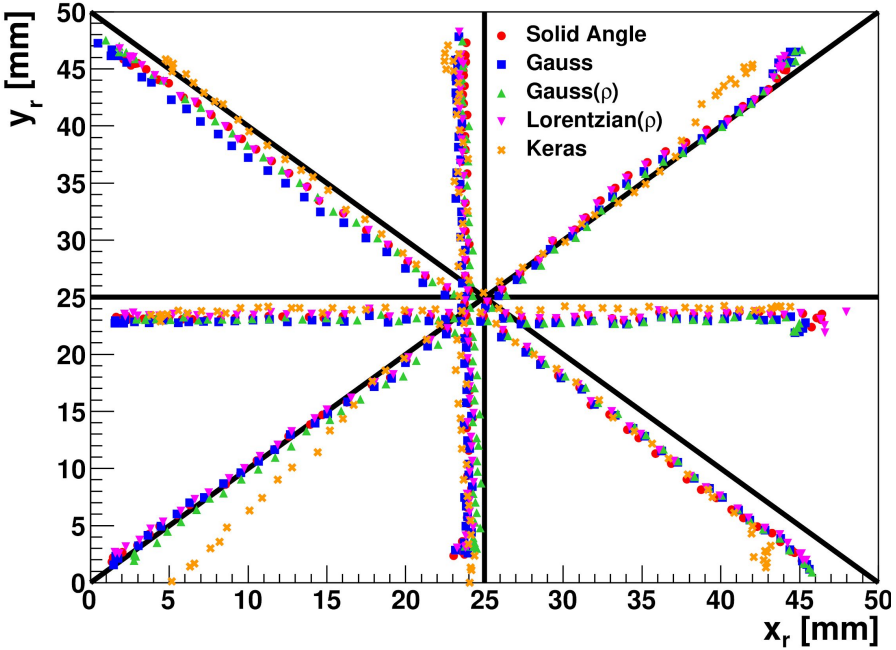
Compression in the output **image**!

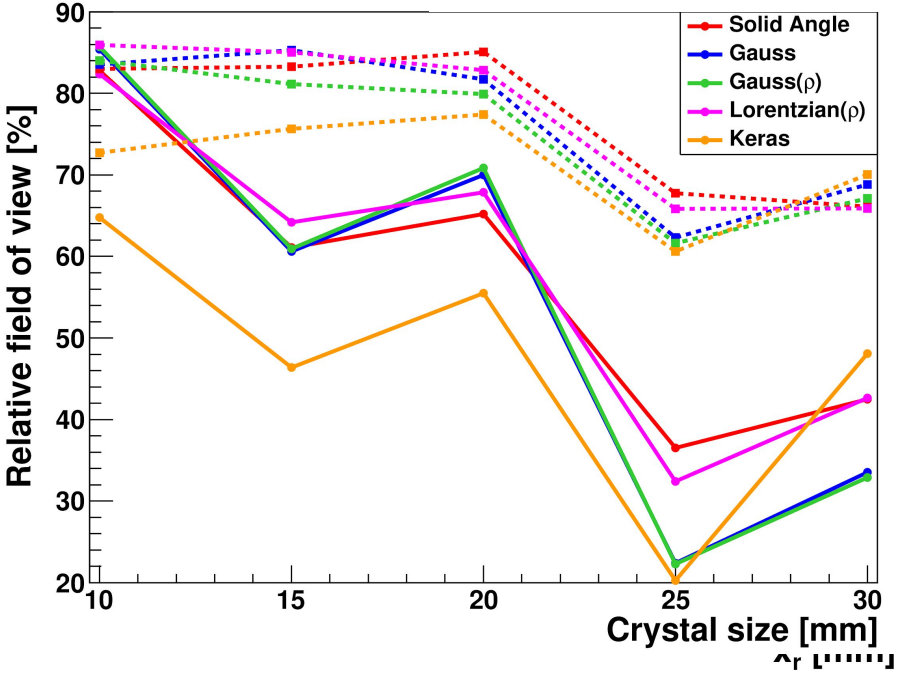
Support **V**ector **M**achine algorithm to decompress

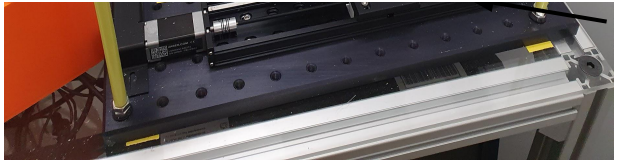
ML applied to position reconstruction

15 mm $LaCl_3$ thickness

http://arxiv.org/abs/2010.13427







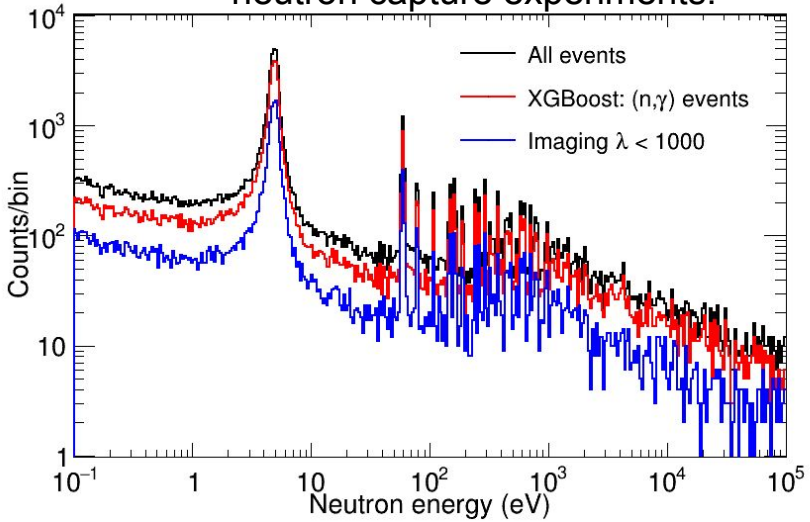
X-Y table

Compression in the output **image**!

Support **V**ector **M**achine algorithm to decompress

ML applied to background rejection

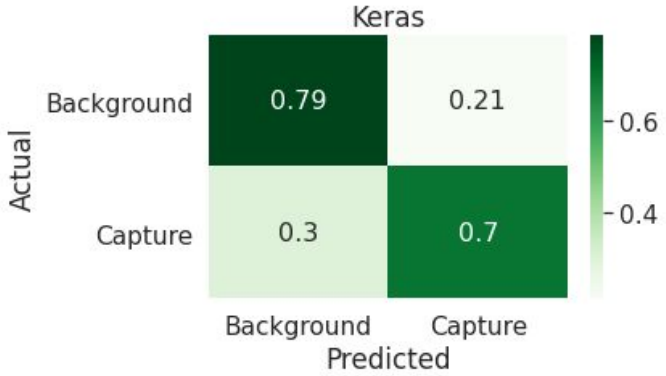
ML algorithms applied to background suppression in real neutron capture experiments:



Accuracy achieved so far:
XGB: **73.98%**
KERAS: **74.32%**

A **paper** on the issue is **in preparation!**

tensorflow+keras



XGB