ATHENA X-IFU event reconstruction: Extreme Learning Machine approach

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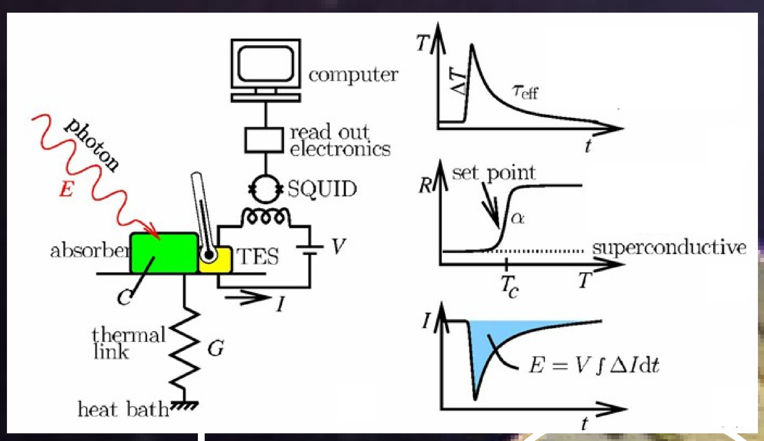
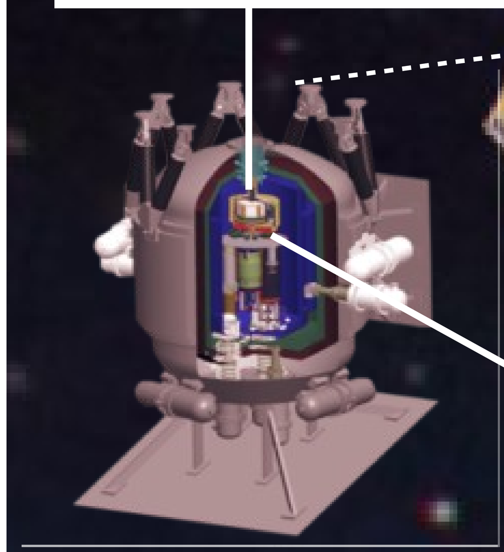
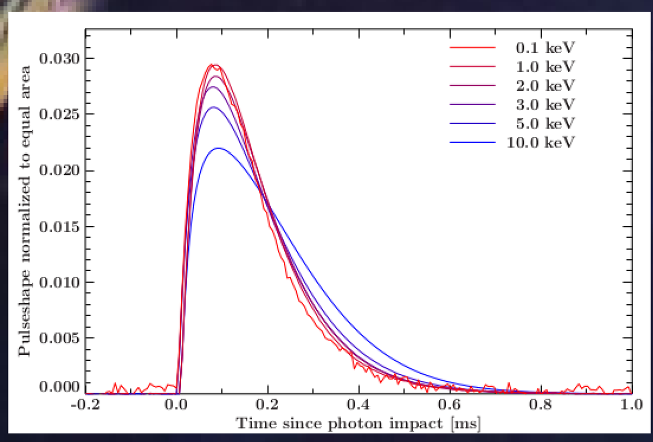
SIRENA is the software aimed at performing the on board event energy reconstruction for the *Athena* calorimeter X-IFU, in the Digital Readout Electronics unit. Processing will consist in an initial triggering of event pulses followed by an analysis (with SIRENA) to determine the energy content of events. Optimal filtering has been chosen as the baseline algorithm but other techniques are still under study in an effort to get the better results at the lower computing cost. Here we show the performance of the Extreme Learning Machine (ELM) algorithm for single-hidden layer feedforward neural networks (SLFNs)







Response of X-IFU microcalorimeter to X-ray incoming photons are electrical pulses.

SIRENA

Triggering algorithm for Pulse Detection [4]

Event Reconstruction (Energy & Energy resolution determination - different algorithms under study) [7]

Pulses must be detected (triggered) and then its energy must be reconstructed on board by the Event Processor in the Digital Readout Electronics Unit by the SIRENA software

Baseline approach

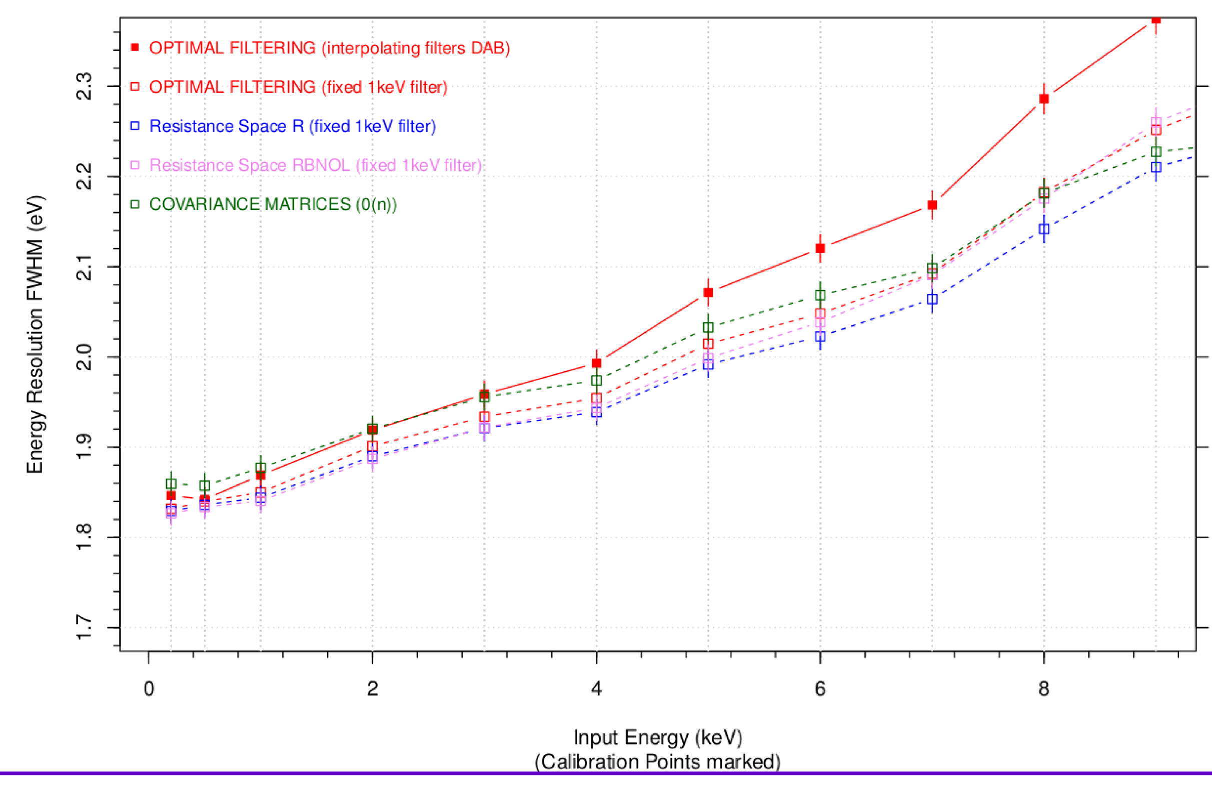
(http://sirena.readthedocs.io)

Optimal Filtering (Resistance Space) [5,6]

Data $D(t) = H \times S(t)$

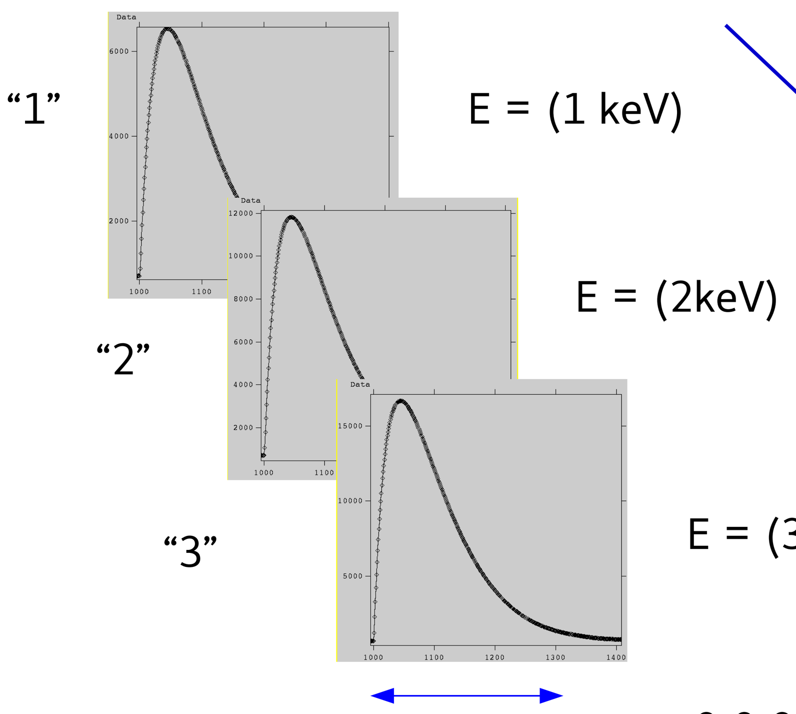
Minimize $\chi^2 = \sum \frac{[D(f) - H \times S(f)]^2}{NOISE^2(f)}$

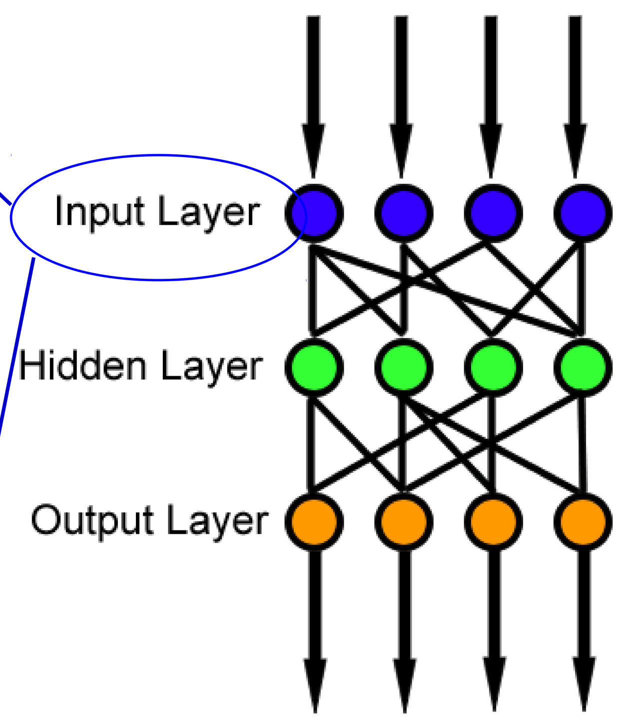
$E \sim \sum D(t)\, OptFil(t)$



Neural Networks: Single Hidden Layer Feed-forward Neural Network

Training and prediction functions use the Extreme Learning Machine (**ELM**) algorithm: random generated weights, very short training times, no need to set learning rate, momentum, epochs. Only tune hidden layer size and learning function



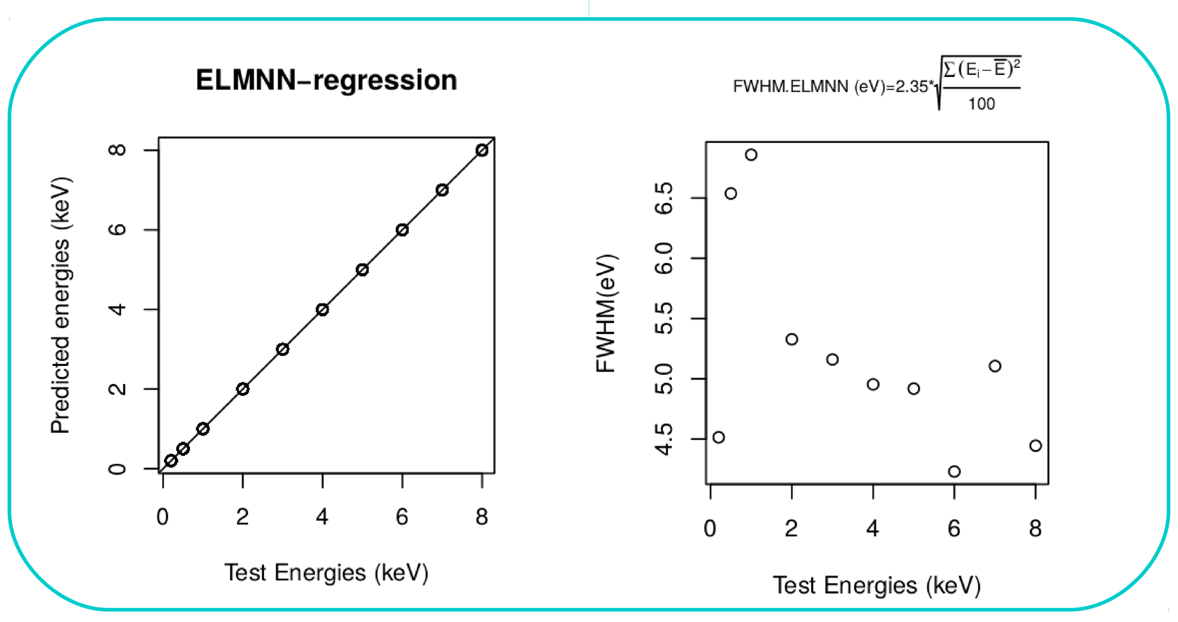


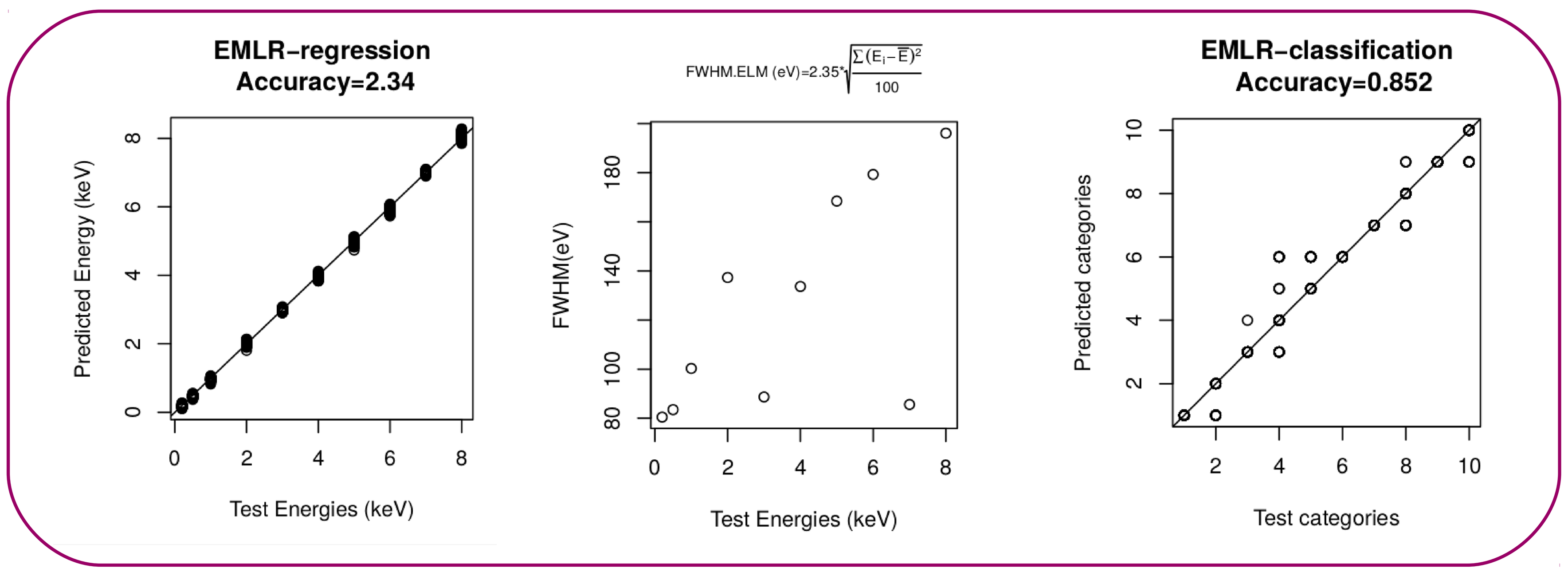
Packages in R

Package	Regression or classification	Activation Function
ELMR[8]	Regression or classification	sigmoid
ELMNN[9]	Regression	Positive linear

Hidden nodes=300

Train data: 1000 pulses/energy
Test data: 100 pulses/energy





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