Software for ATHENA: IFU event reconstruction

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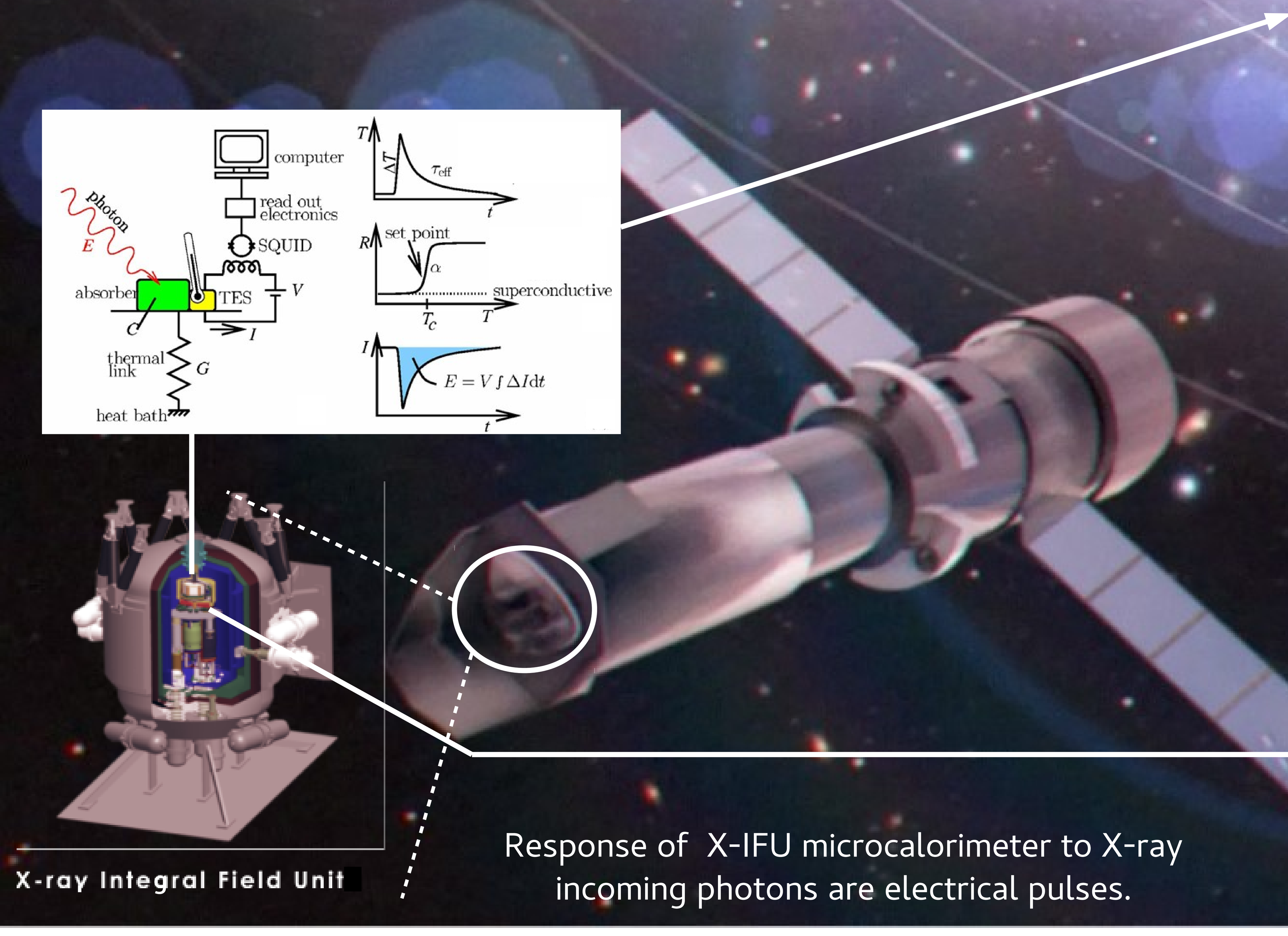
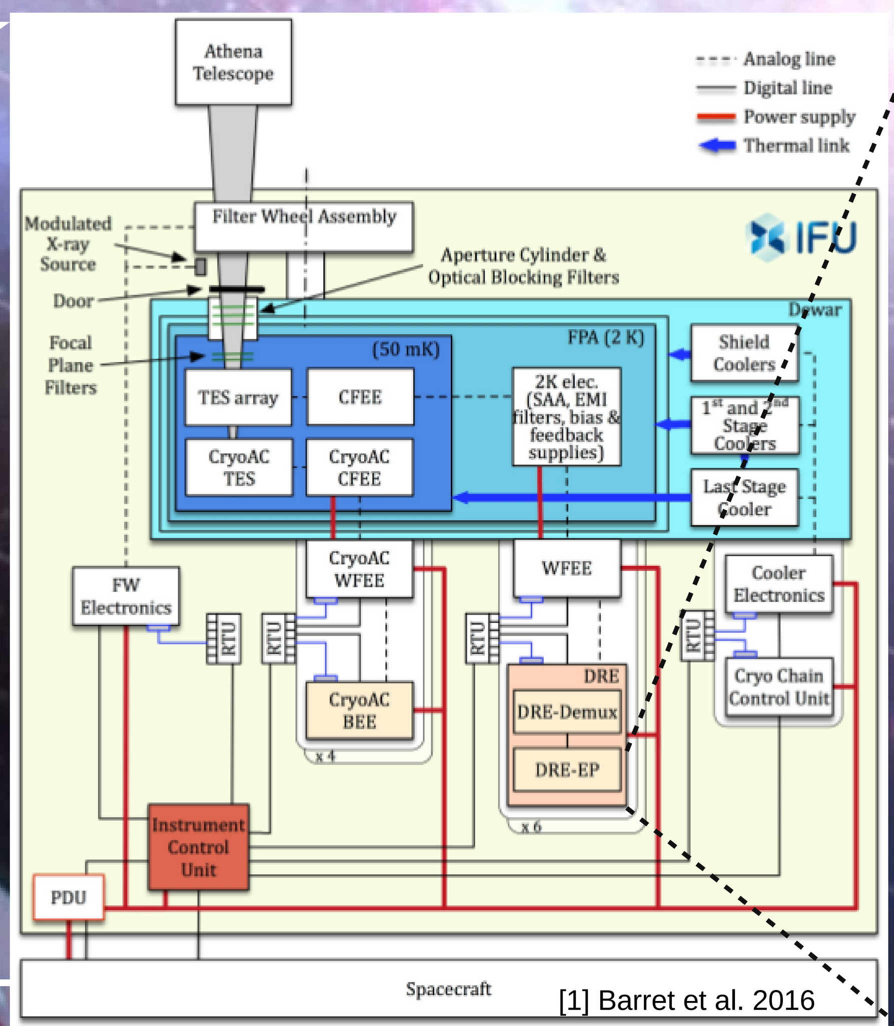
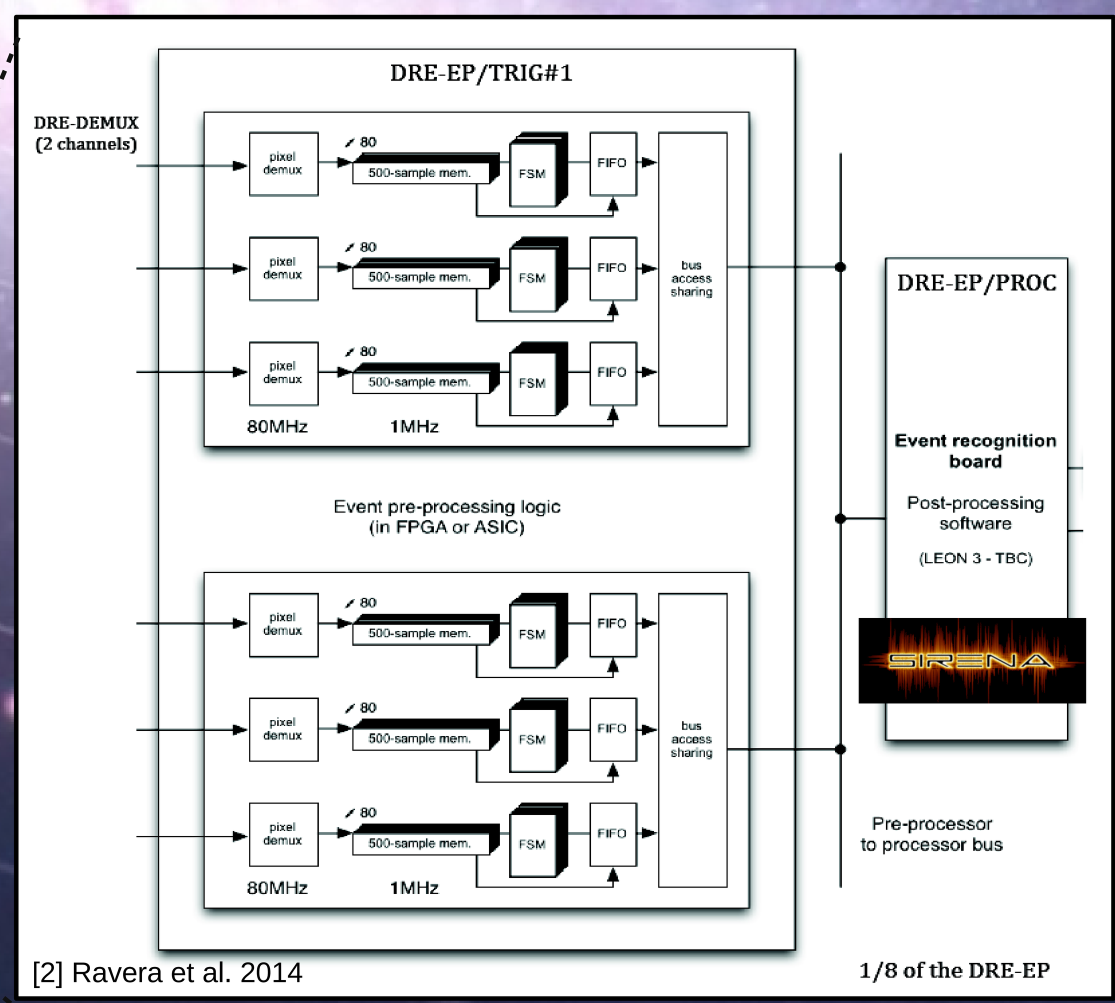
SIRENA is the software aimed at performing the on board event energy reconstruction for the *Athena* calorimeter X-IFU. This on board processing will be done in the X-IFU Digital Readout Electronics (DRE) unit and it will consist in an initial triggering of event pulses followed by an analysis (with the SIRENA package) to determine the energy content of such events.



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





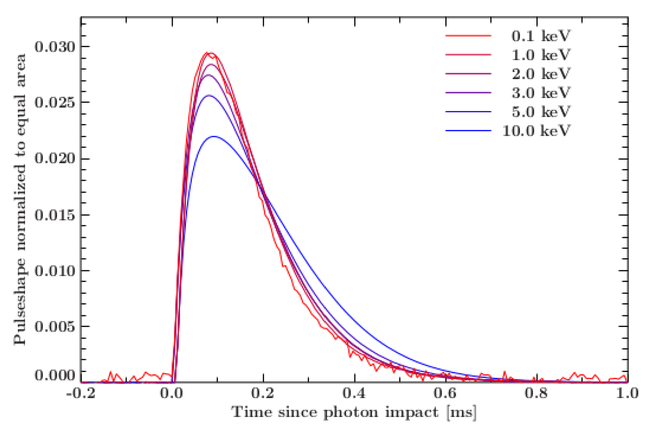
Pulses must be detected (triggered) and then its energy must be reconstructed on board by the Event Processor in the Digital Readout Electronics Unit by the SIRENA software

Development under **SIXTE** environment for end-to-end simulations

http://www.sternwarte.uni-erlangen.de/research/sixte/index.php

Simulation of X-IFU TES physics (tool: **tessim**)

Numerical solution of differential equations for T (t) , I(t)[3]



Triggering algorithm for Pulse detection [4]

Event Reconstruction (Energy & Energy resolution determination - different algorithms under study)[11]

RECONSTRUCTION METHODS

http://venus.ifca.unican.es/SIRENA/

Optimal Filtering [5,6]

✗ Pulses are scaled versions of a single shape: Response of detector is linear
✗ Noise is stationary

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

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

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

Covariance Matrices [7,8]

* Least squares optimal filter varying with photon energy. Accounts for noise non-stationarity & detector non-linearity
* Calibration with densely spaced narrow lines
Model template (M) + covariance matrix (C; deviations from model) + weight matrix (W=C⁻¹)

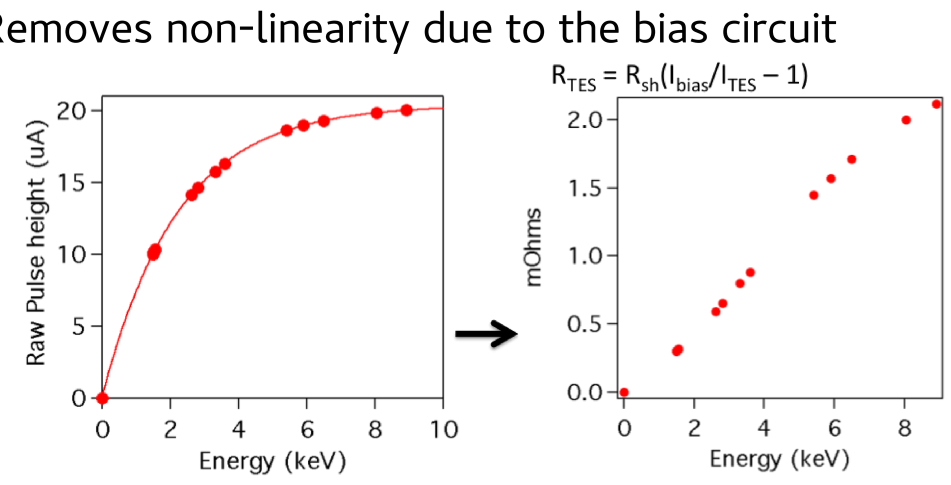
$$Minimize \quad \chi^2 = (Data - M)\, W\, (Data - M)$$

$$Energy = f(E_\alpha, E_\beta, U, M_\alpha, M_\beta, W_\alpha, W_\beta)$$

α,β: calibration points that straddle the unknown signal U

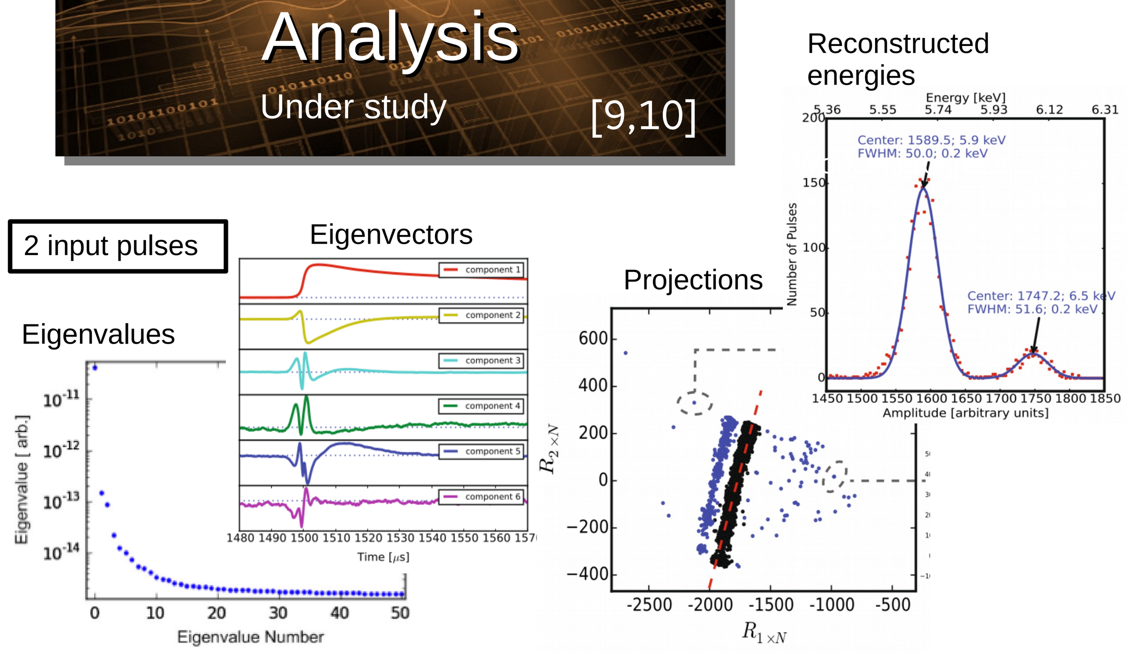
Resistance Space [9]

✓ Optimal Filter after transforming signal I_{TES} to R_{TES}:
Removes non-linearity due to the bias circuit



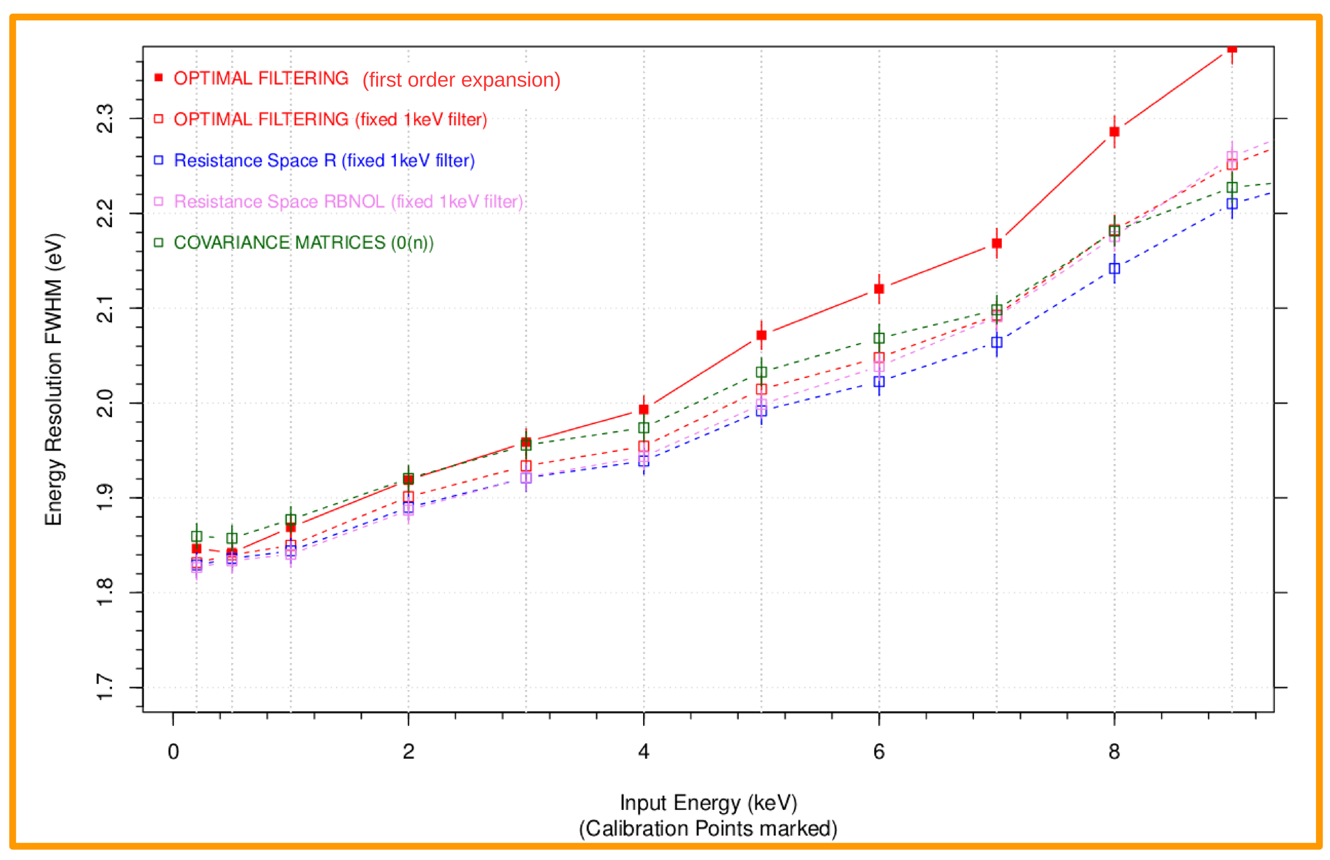
Principal Component Analysis [9,10]

Under study



COMPARATIVE

* resolution performance (similar)
* computational cost (larger for covariance)
* calibration needs (larger for covariance)
* automation (more difficult for PCA)
* robustness at high count rates
* response to detector nonlinearity (resistance)



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