24th AGATA Week
Status of the optimization of the Energy pre-processing

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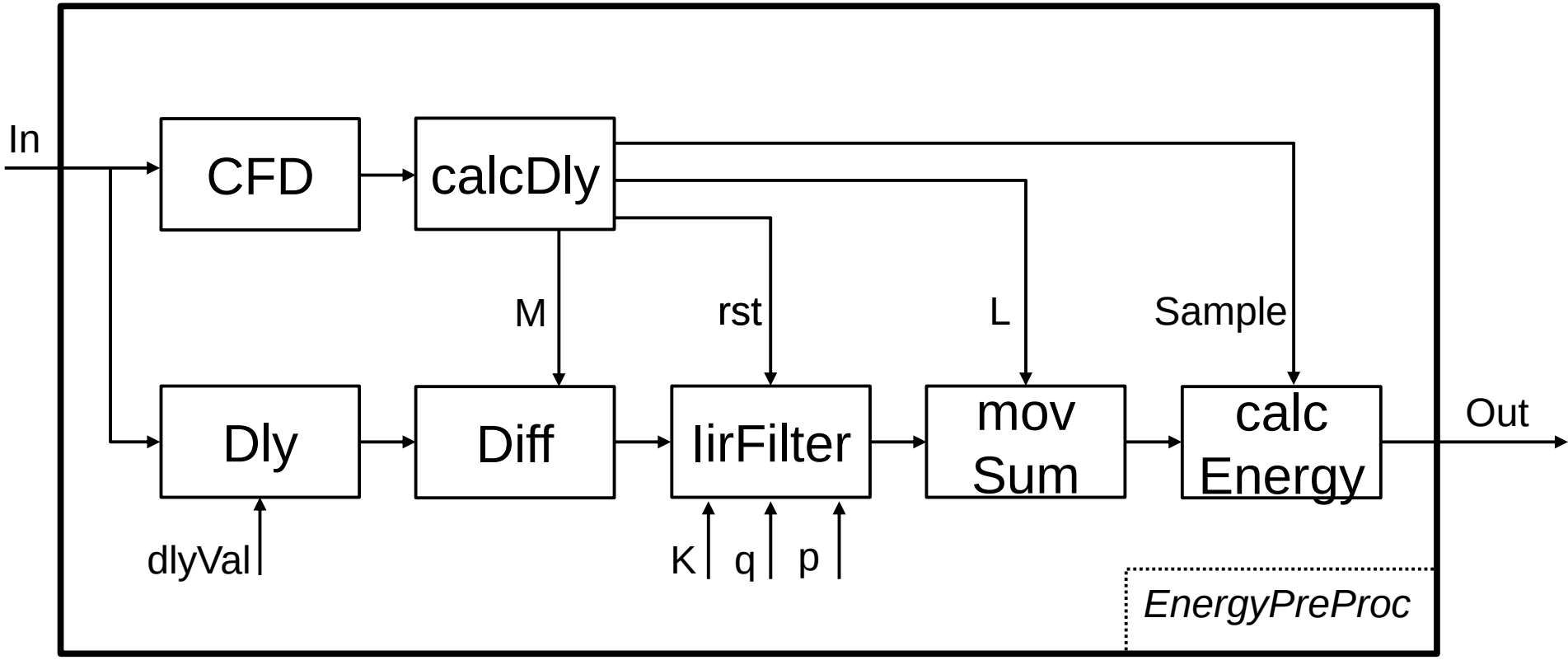
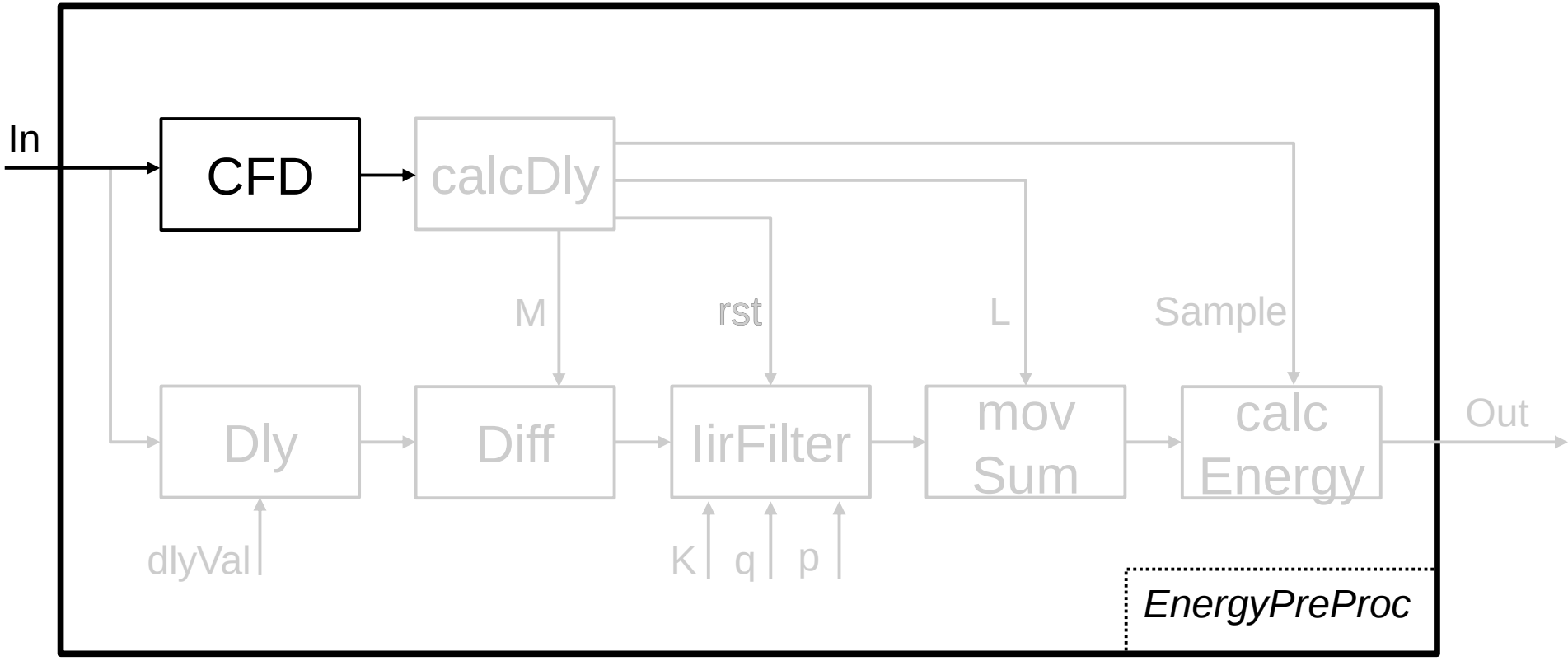
Science & Technology Facilities Council
Nuclear Physics Group

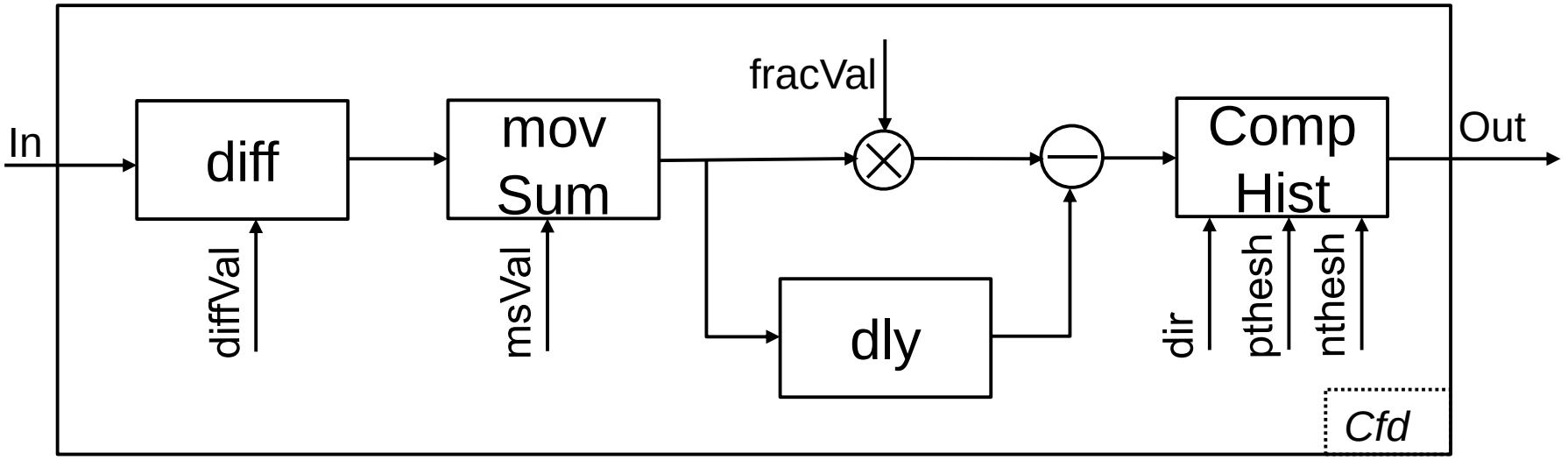
Energy pre-processing



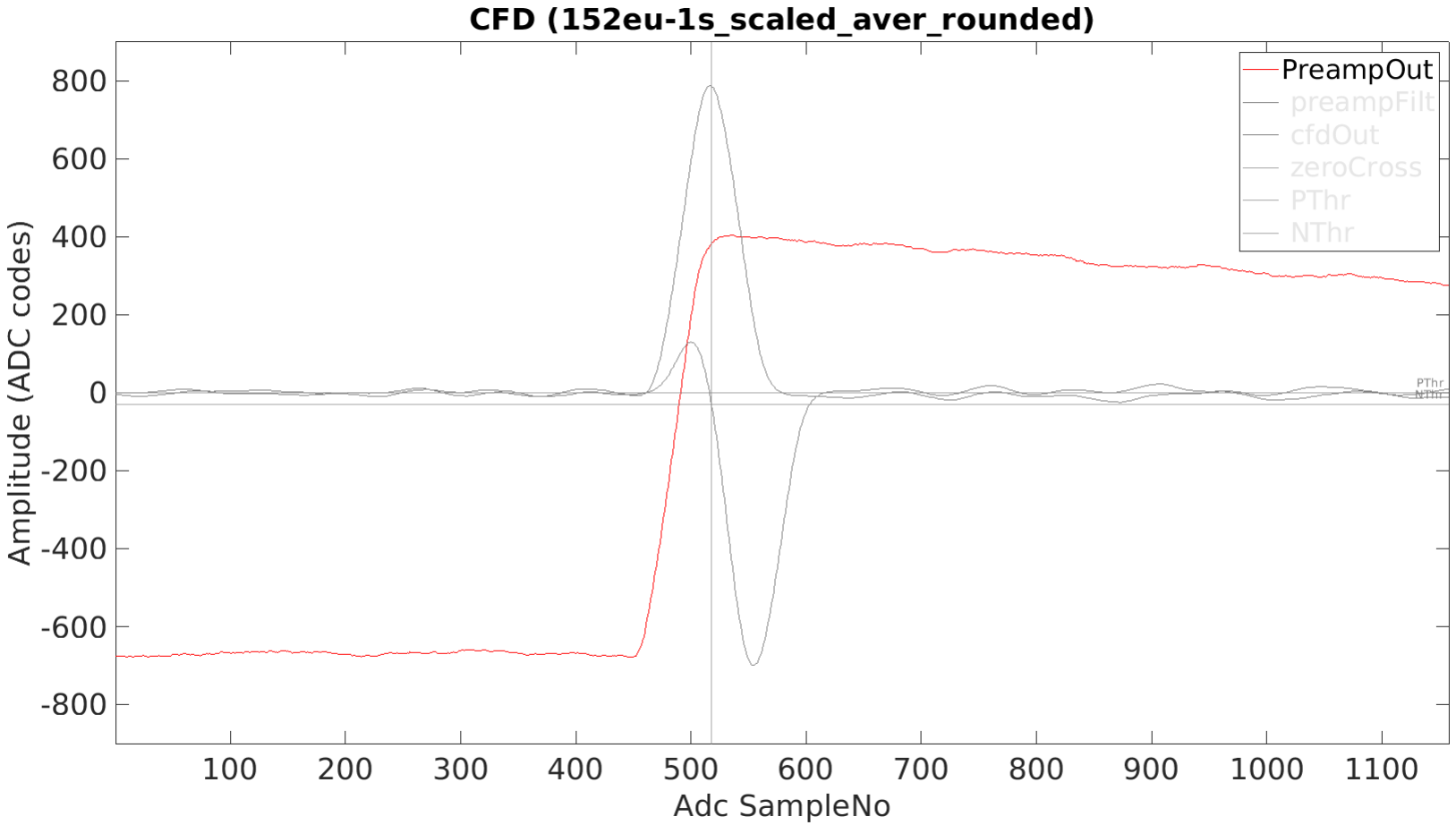
Constant Fraction Discriminator (CFD)



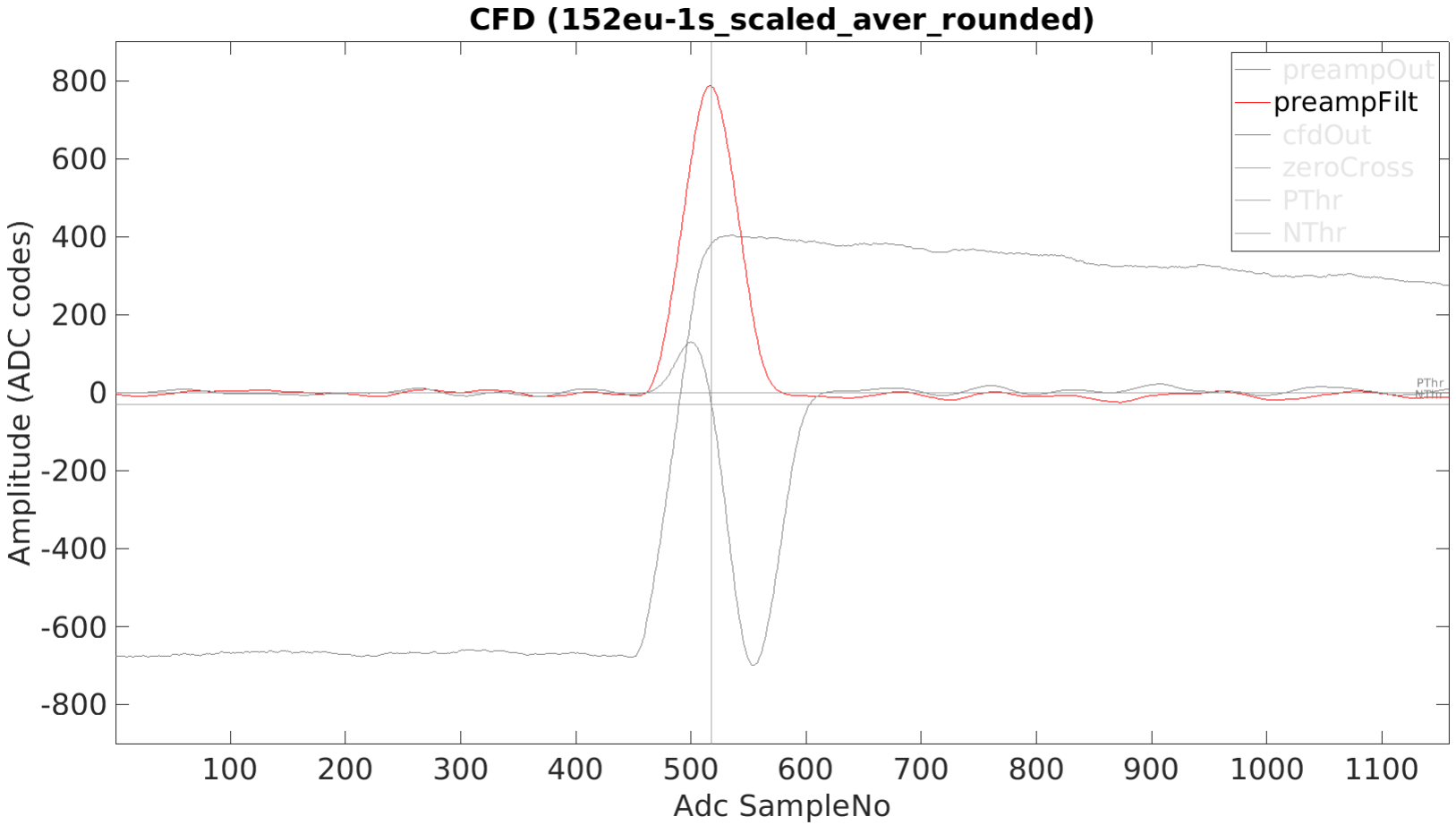
Constant Fraction Discriminator (CFD)



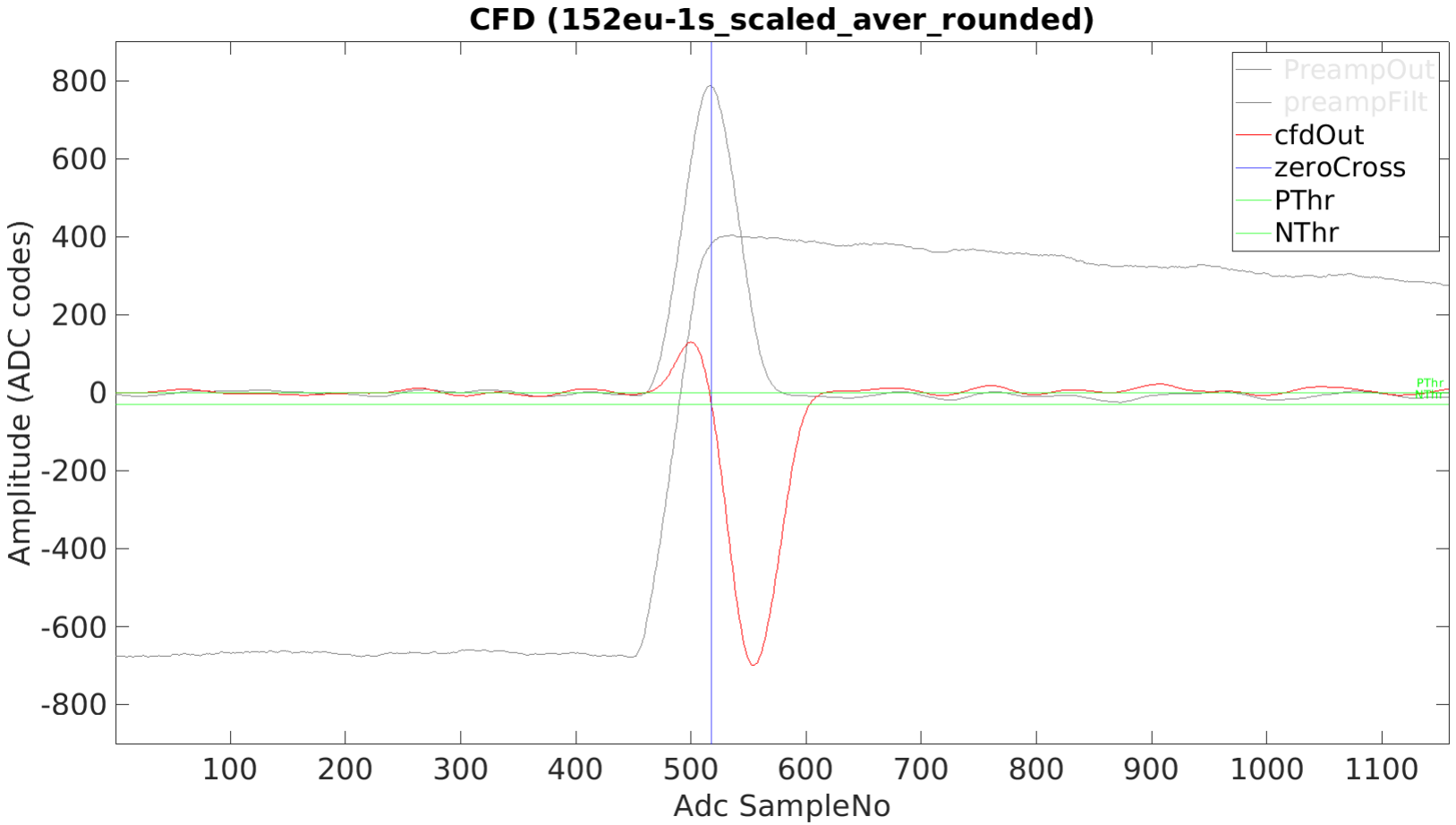
Constant Fraction Discriminator (CFD)



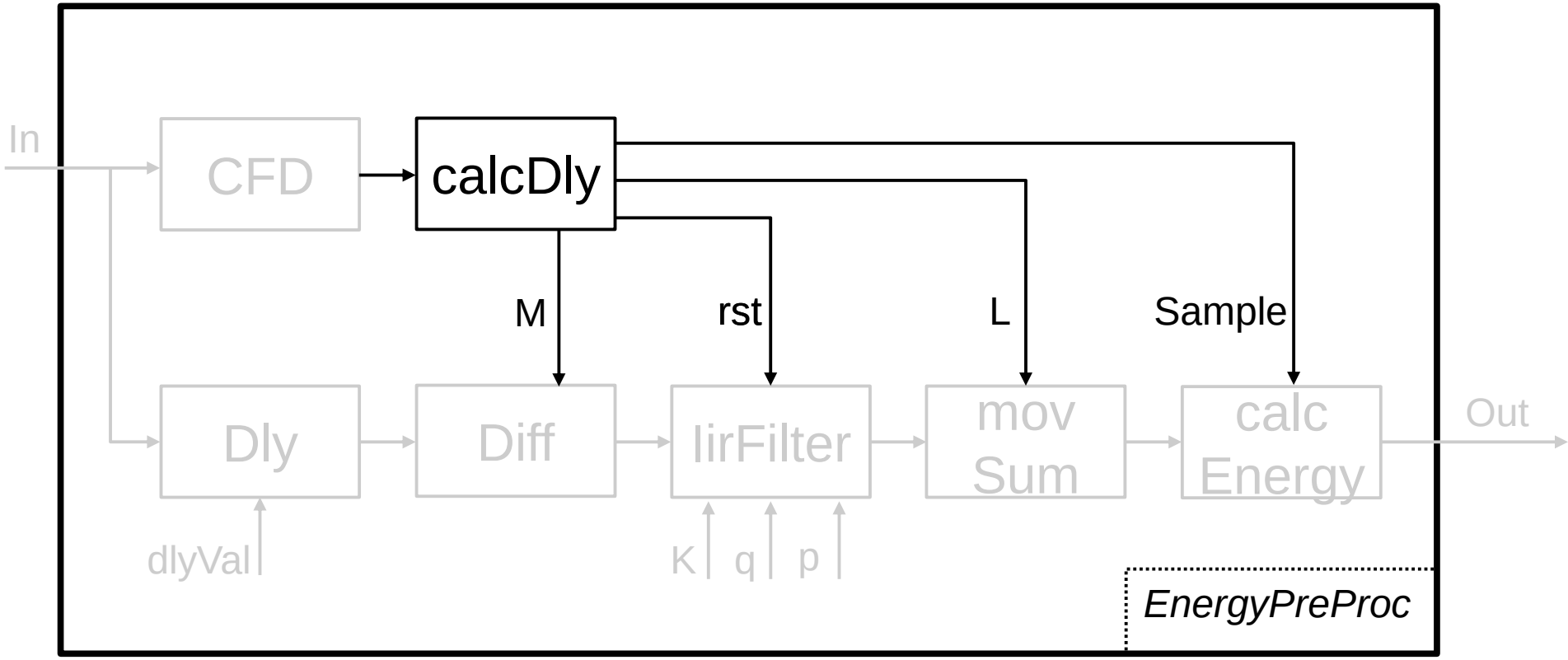
Constant Fraction Discriminator (CFD)



Constant Fraction Discriminator (CFD)



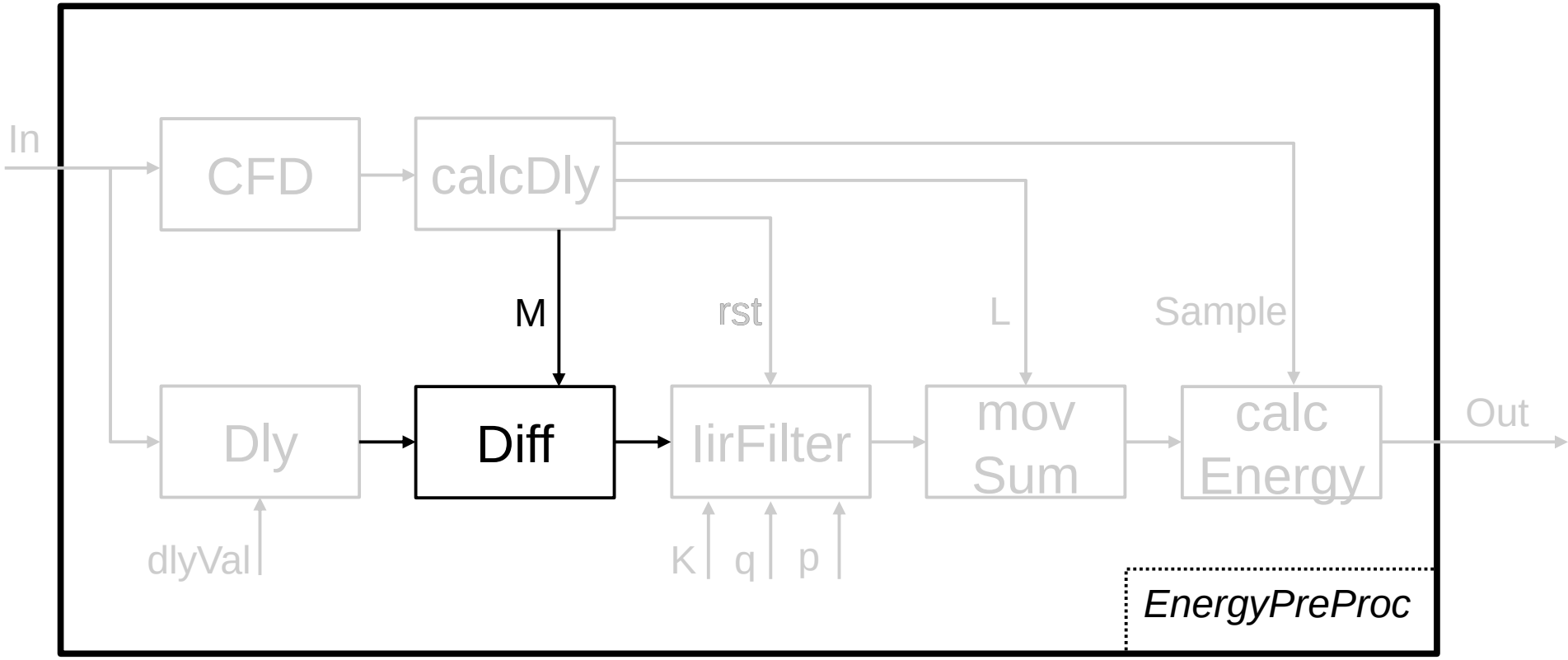
Delay calculation Block



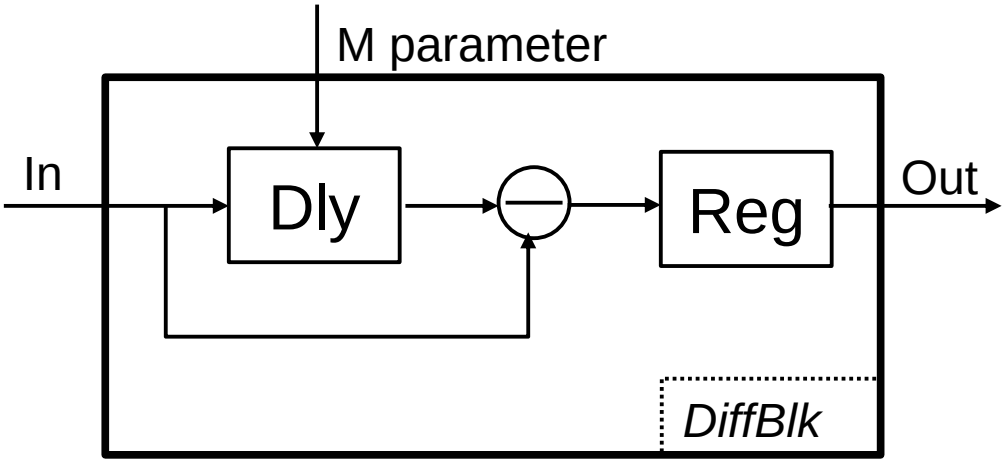
Delay calculation Block

- Counts the period b/w cfd triggers (up to a max. value, set by the user).
- Compares the current period with previous one and selects the smallest one of the two.
- The smallest period is then halved and the point to loaded to the Diff Blk is also calculated.

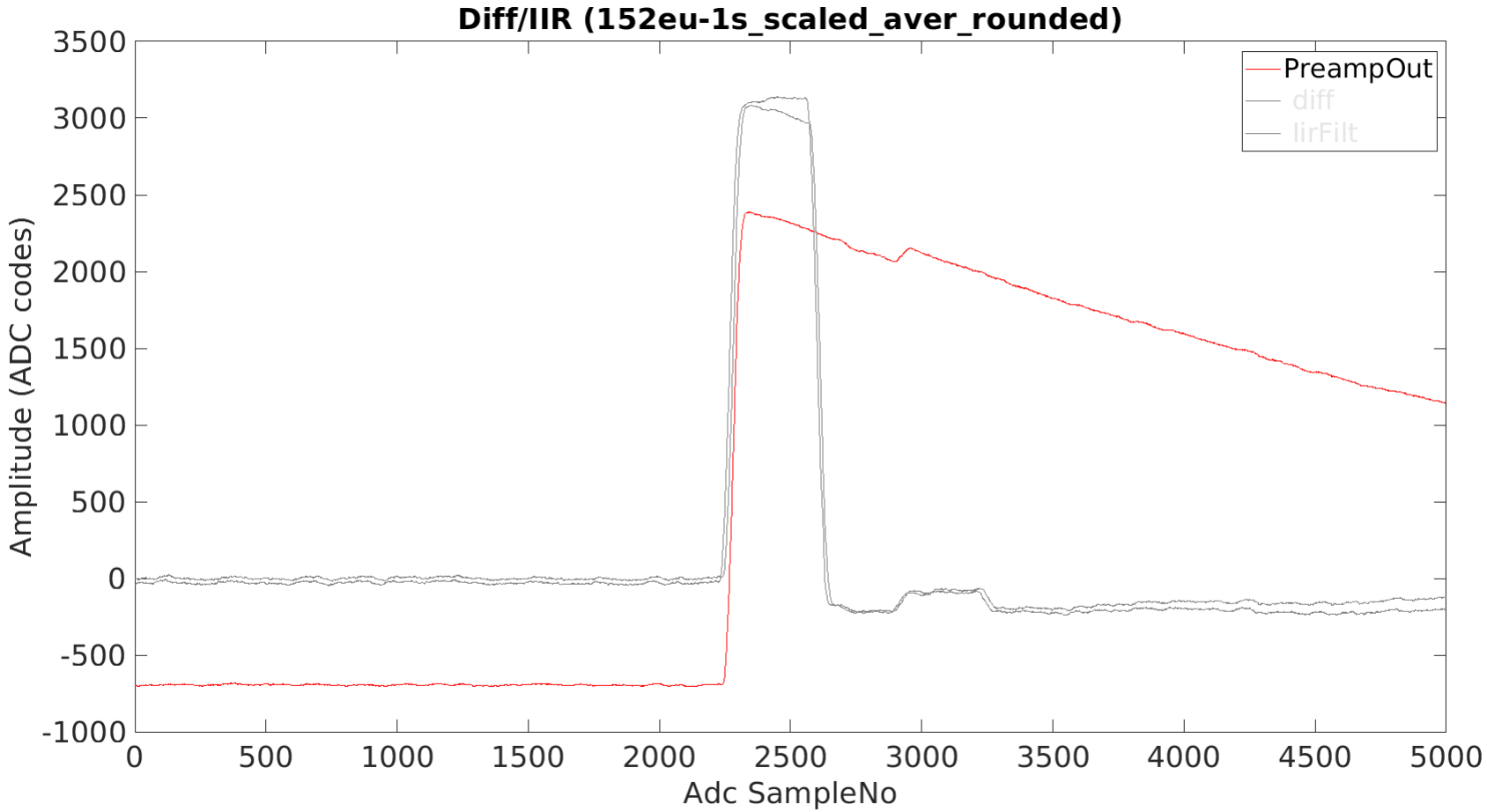
Differential Block



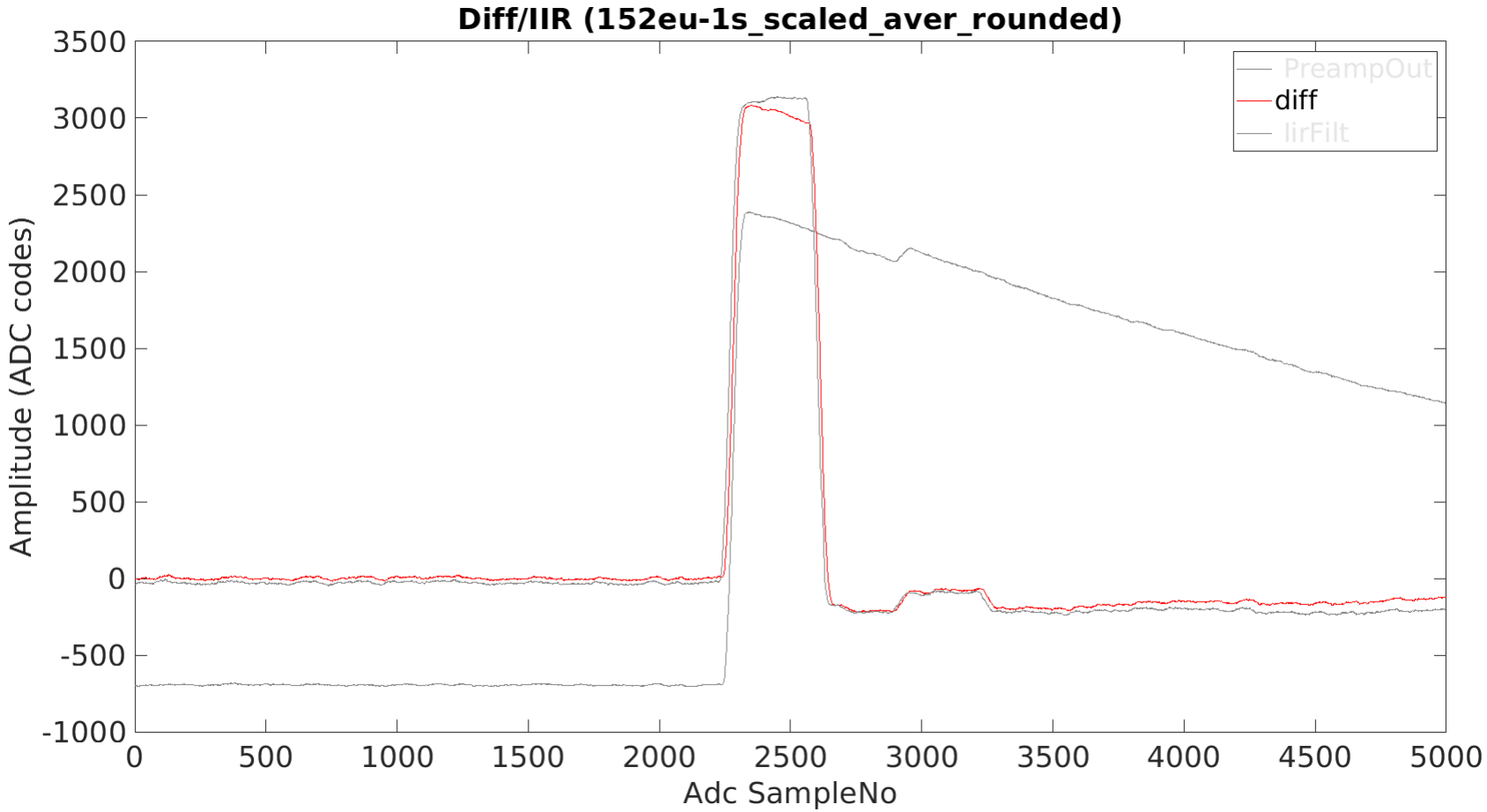
Differential Block



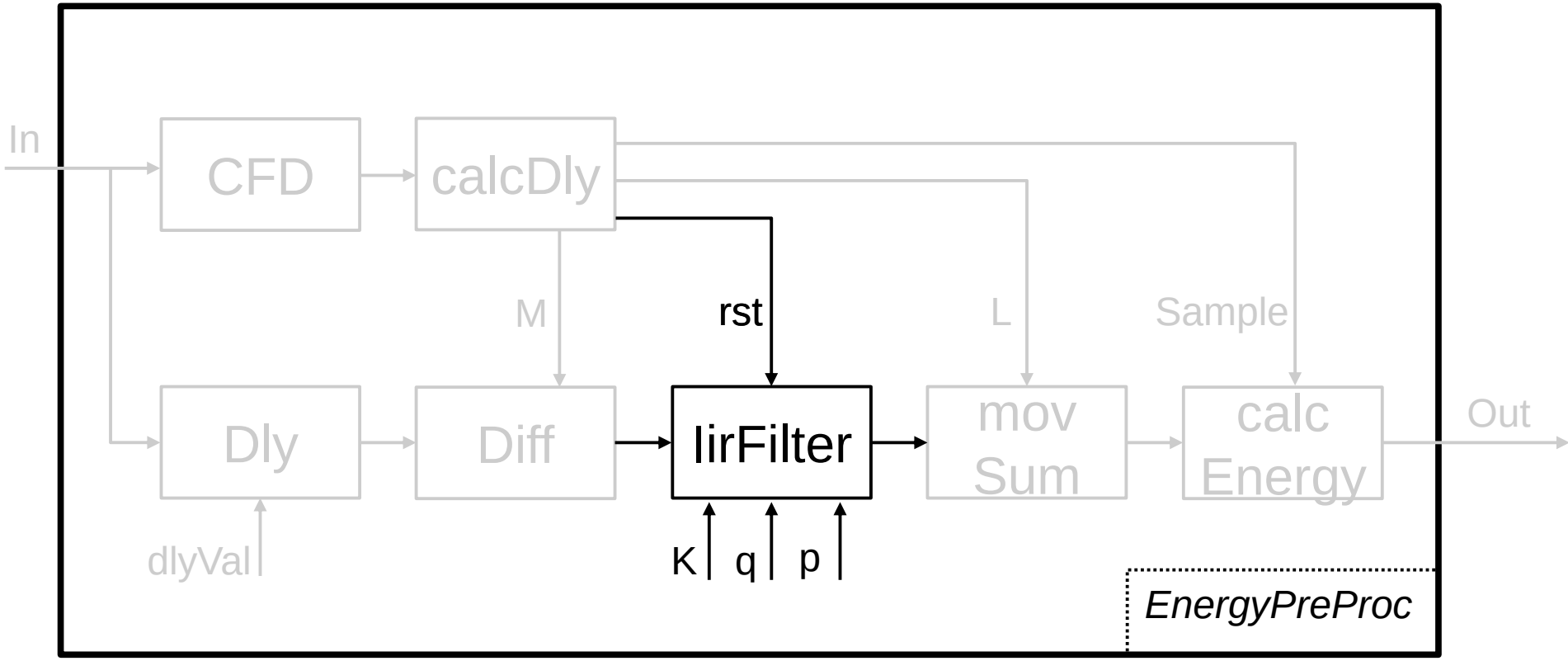
Differential Block



Differential Block



IIR Filter


In
CFD
calcDly
M
rst
L
Sample
Dly
Diff
IirFilter
mov Sum
calc Energy
Out
dlyVal
K
q
p
EnergyPreProc

IIR Filter

- A more general approach is to estimate the transfer function of the pre-amplifier output using higher order models.
- Then calculate the inverse transfer function.
- Convert the inverse transfer function to the z^-1 domain.
- So for a 3rd order model:

$$H(z) = \frac{Y(z)}{X(z)} = \frac{b_0 + b_1 z^{-1} + b_2 z^{-2}}{1 + a_1 z^{-1} + a_2 z^{-2}}$$

- The above tranfer function can then be implemented as an Infinite Impulse Response (IIR) filter [Ref.2].

Transfer function Factorization

So for a 3rd order model, transfer function is:

$$H(z) = \frac{Y(z)}{X(z)} = \frac{b_0 + b_1 z^{-1} + b_2 z^{-2}}{1 + a_1 z^{-1} + a_2 z^{-2}}$$

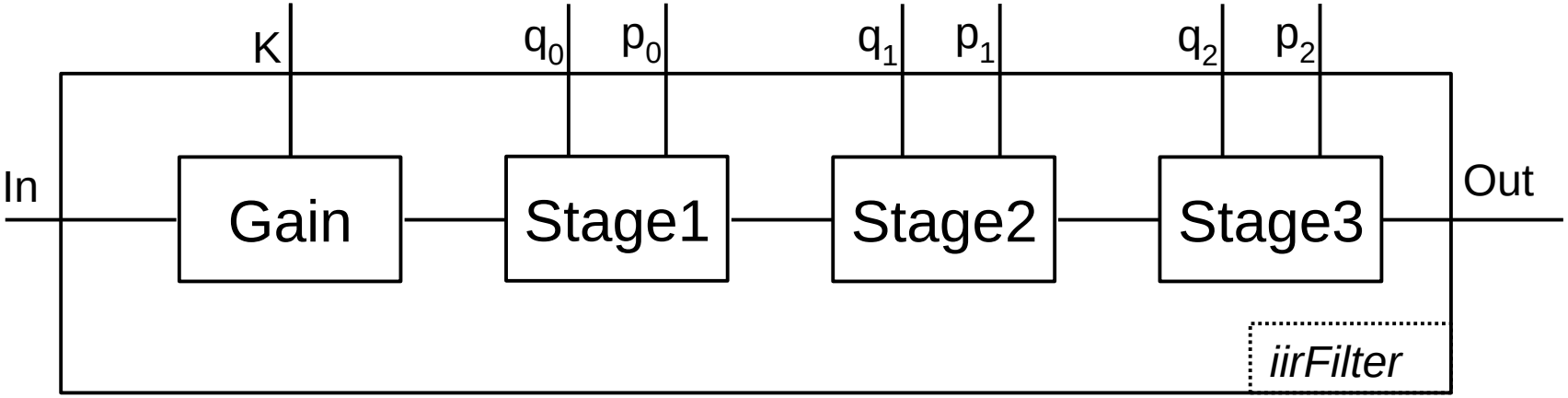
Factorise above transfer function to:

$$H(z) = \frac{Y(z)}{X(z)} = K \frac{(1 - q_0 z^{-1})(1 - q_1 z^{-1})(1 - q_2 z^{-1})}{(1 - p_0 z^{-1})(1 - p_1 z^{-1})(1 - p_2 z^{-1})}$$

K = gain
q = zeros
p = poles

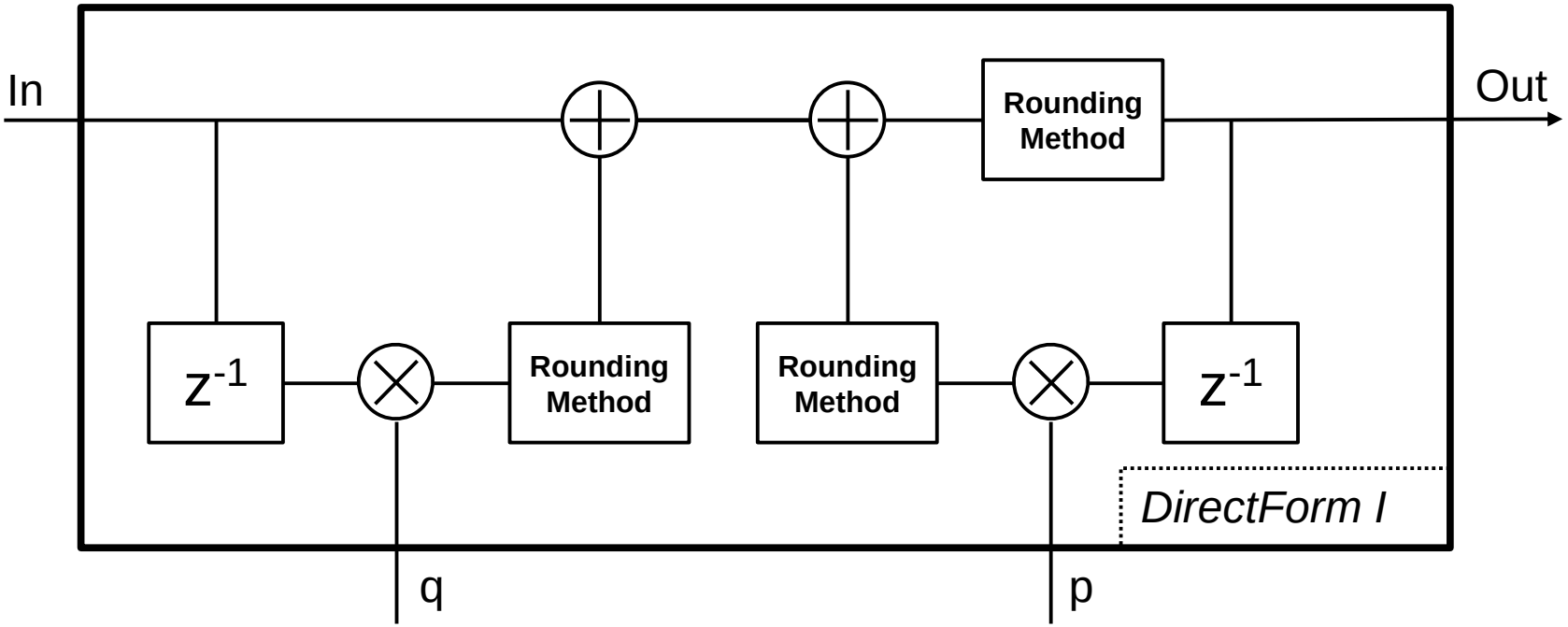
Implementation

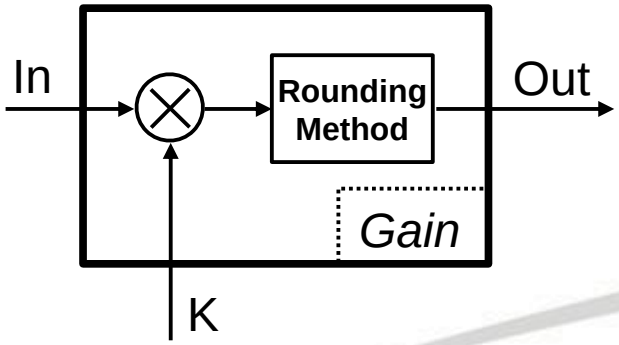
Cascade of first order filters:



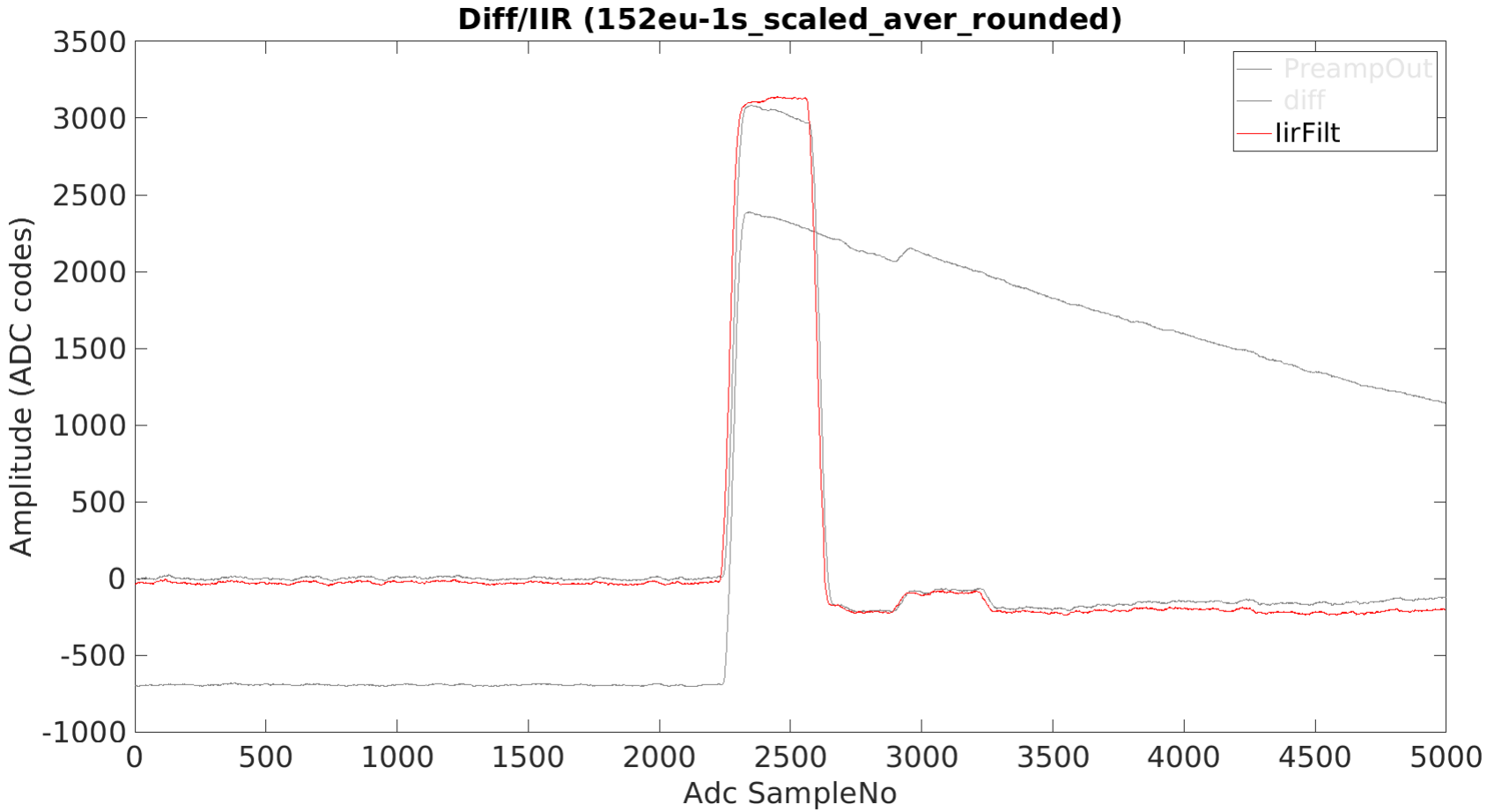
K = gain
q = zeros
p = poles

Direct form I

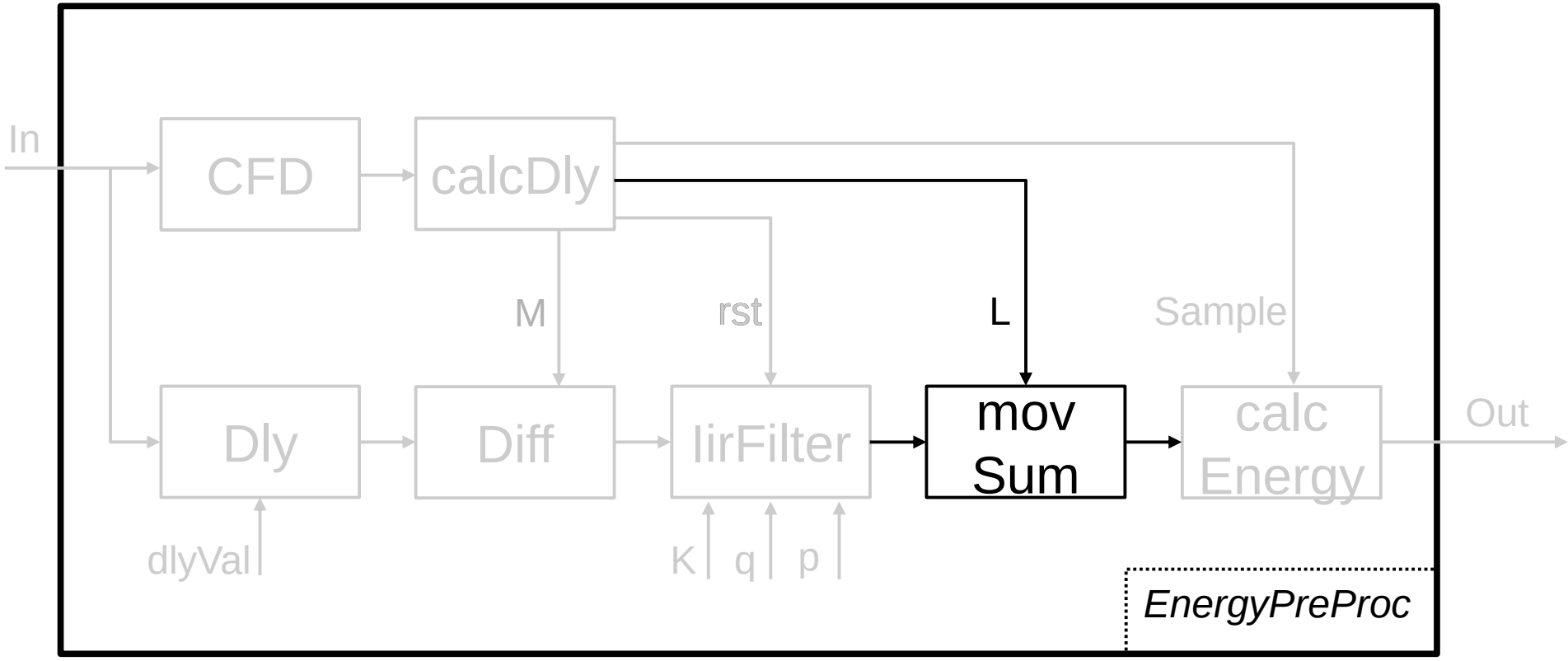




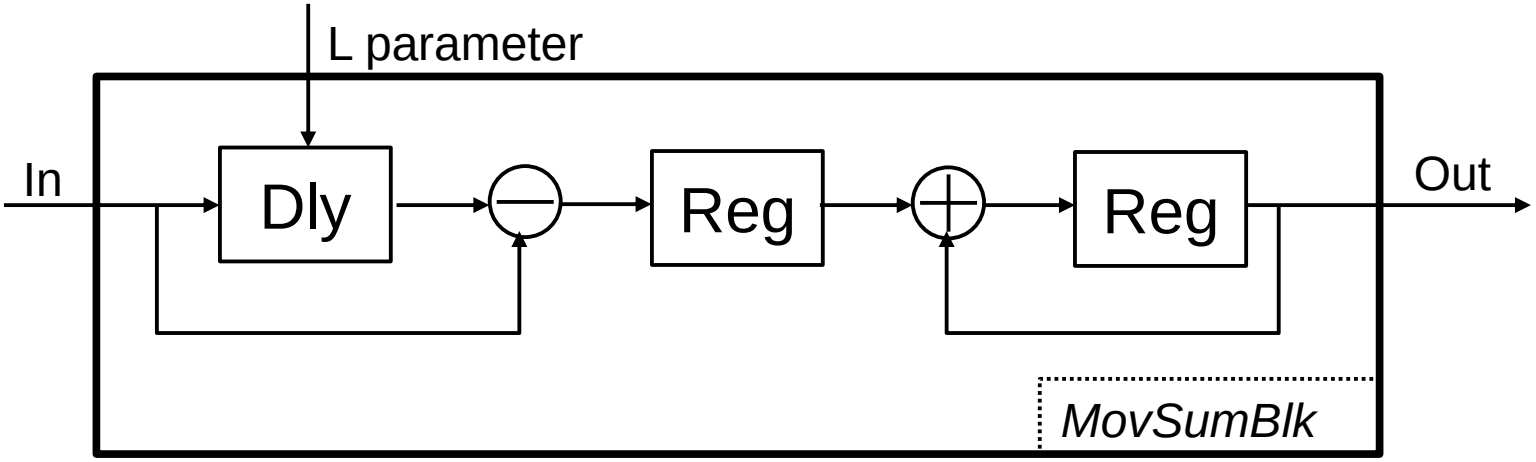
IIR Filter


Diff/IIR (152eu-1s_scaled_aver_rounded)
PreampOut
diff
IirFilt
Amplitude (ADC codes)
Adc SampleNo
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

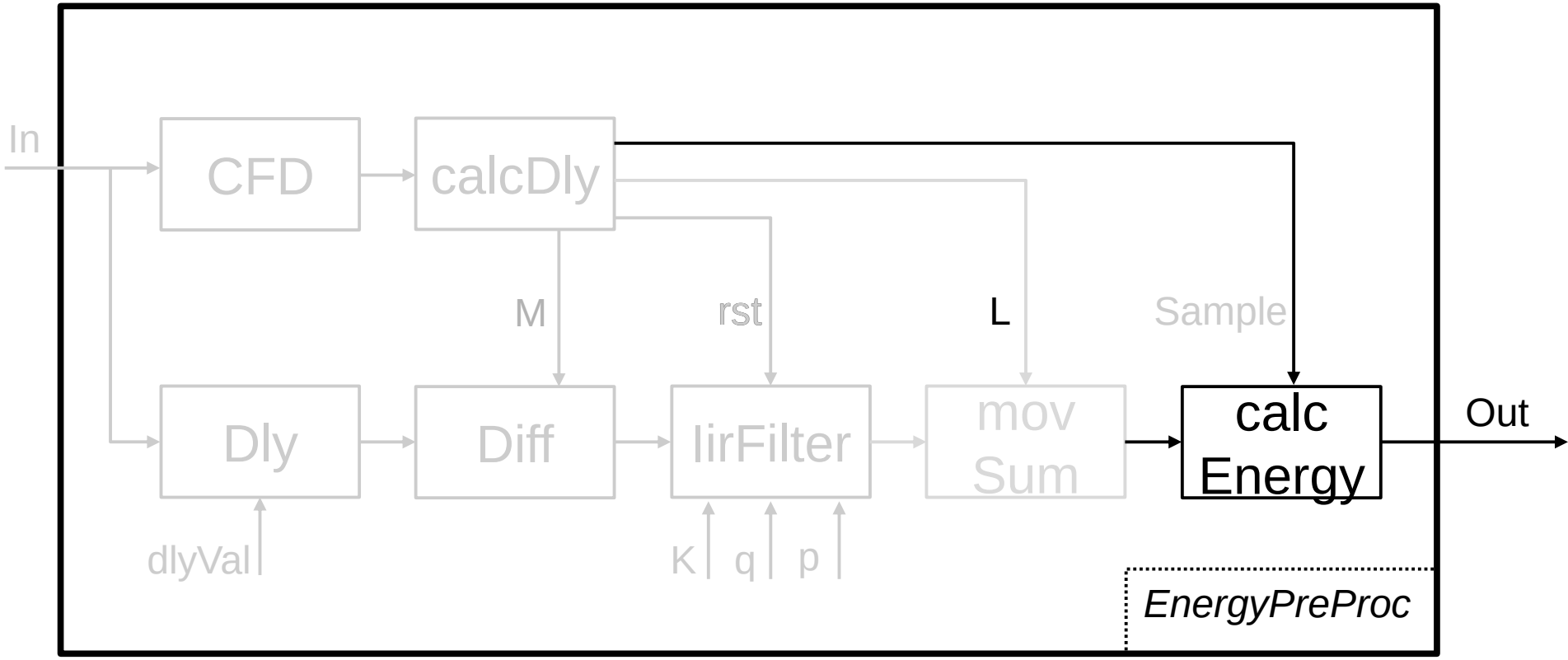
Moving Sum Block



Moving Sum Block



Energy Calc


In
CFD
calcDly
M
rst
L
Sample
Dly
Diff
IirFilter
mov Sum
calc Energy
Out
dlyVal
K
q
p
EnergyPreProc

ToDo

- Adjust the Moving Average (L) parameters depending on the duration of events and calculate the energy.
- Baseline restoration.
- Require longer traces from detectors, with multiple events per core/segment trace.

References

1. EnergyProcessing.pdf, courtesy of Emmanuel Clement.

2. P.Födisch et al., “Digital high-pass filter deconvolution by means of an infinite impulse response filter”, Nuclear Instruments and Methods in Physics Research Section A, 2016.