Istituto Nazionale di Fisica Nucleare
SEZIONE DI TORINO

Studies about the ASIC architecture: code update

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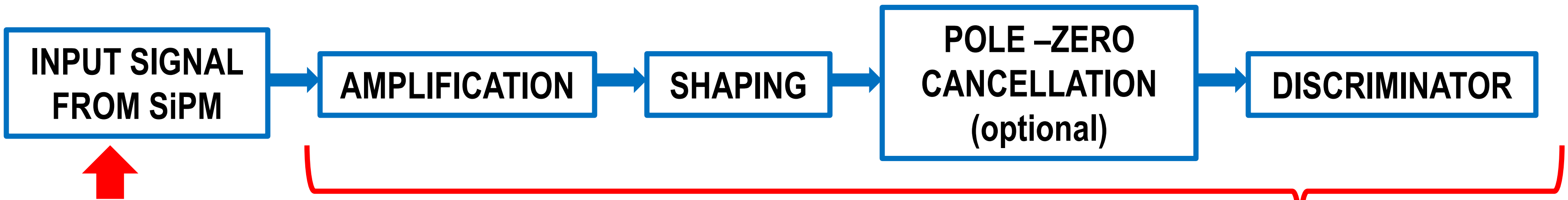
BEHAVIORAL MODEL

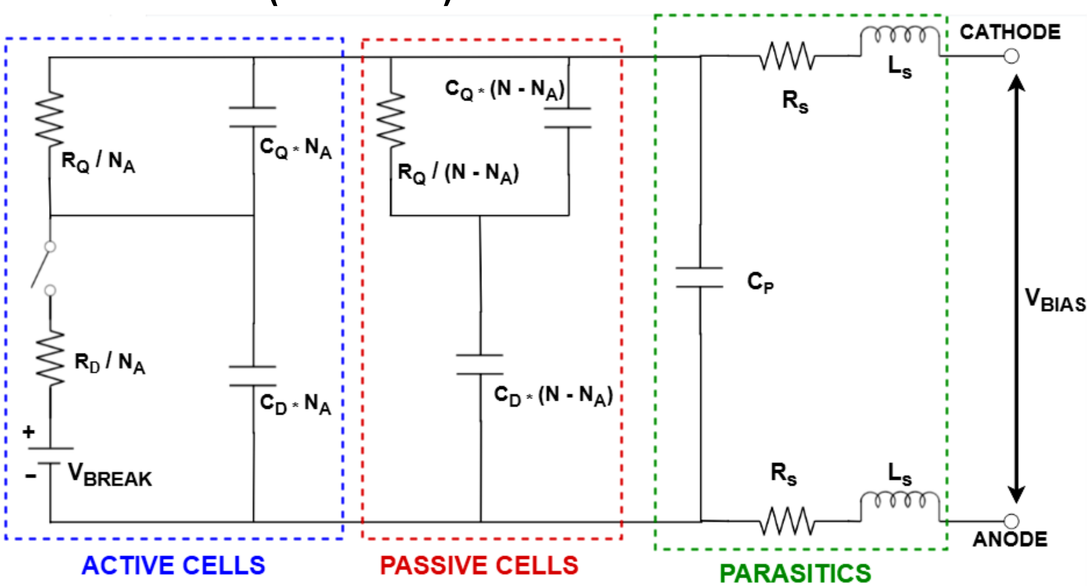
BEHAVIORAL MODEL: set of equations that capture the operation of a circuit from its terminals

PURPOSE: implementation of a time-based readout front end for the analysis of different cases



SiPM ELECTRICAL MODEL: Circuit implemented in virtuoso schematic (Cadence)

Implementation through a **python code in progress**



BEHAVIORAL MODEL

PURPOSE: implementation of a time-based readout FE for the analysis of different cases

QUENCHING RESISTANCE

		R_Q = 0.5 MΩ	R_Q = 1 MΩ	R_Q = 1.5 MΩ	R_Q = 2 MΩ
SiPM AREA	1 x 1 mm²				
	2 x 2 mm²				
	3 x 3 mm²				

TABLE OF RESULTS FOR DIFFERENT CASES

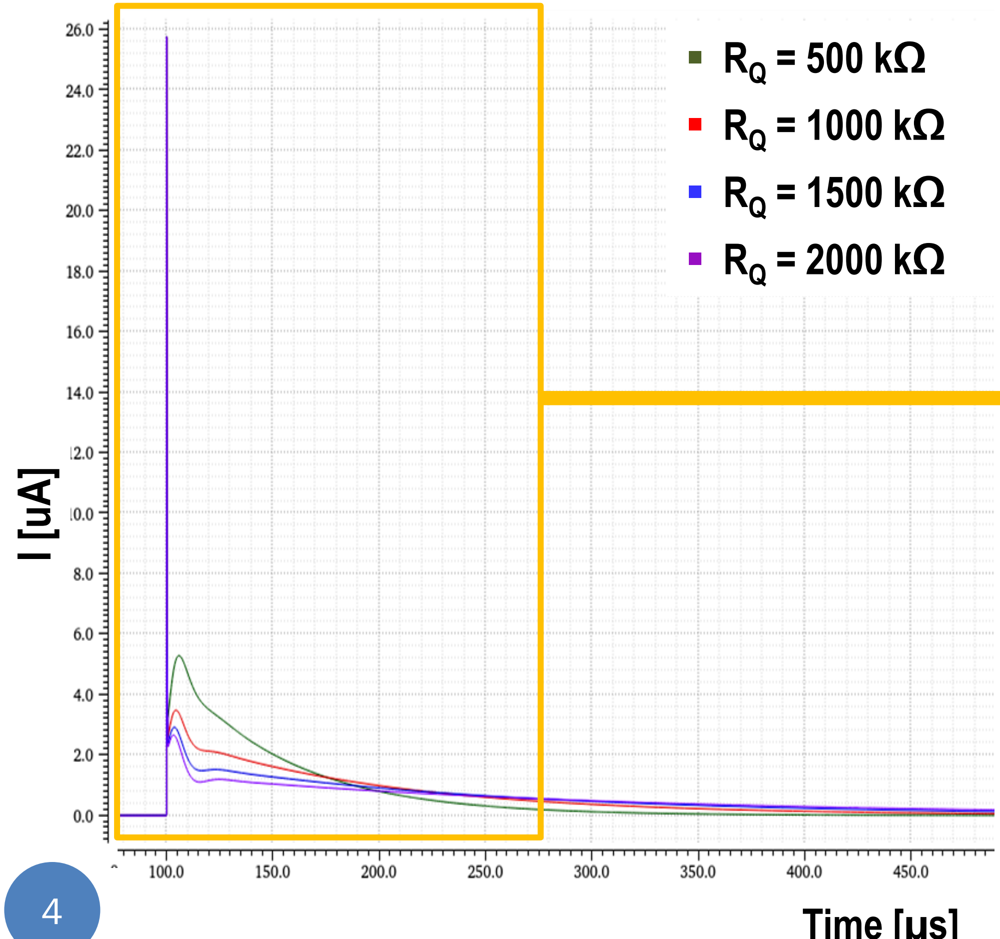
MAIN PREVIOUS QUESTIONS:

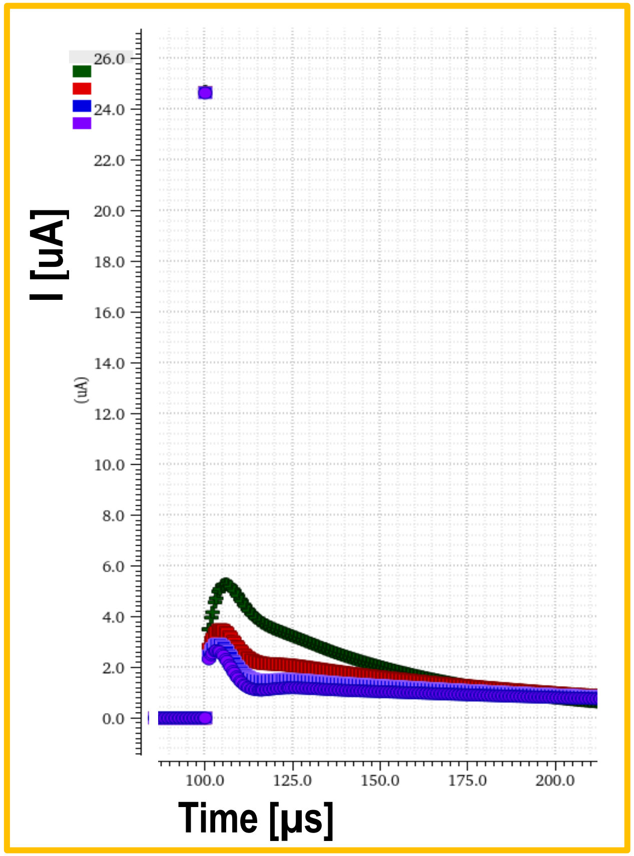
- HOW THE OUTPUT WAVEFORM HAS TO BE (ARCHITECTURE)
- HOW DISCRIMINATOR HAS TO WORK

BEHAVIORAL MODEL

INPUT SIGNAL FROM SiPM ELECTRICAL MODEL → **SAMPLING (bin size = 10 ps)**

Area 3x3 mm^2 (N microcells = 3584)





BEHAVIORAL MODEL

PYTHON CODE STRUCTURE

TBRChain_class.py → TBRChain_main.py

↓

FUNCTIONS:

A. Convolution of the sampled input signal with the amplifier transfer function (completed)
B. Fit of the tail to provide the time constant for pole 0 cancellation (fit step completed, application of pole 0 cancellation on signal needs tuning)
C. Construction of a spill from timestamp files (completed)
D. Discrimination (with threshold and hysteresis)

BEHAVIORAL MODEL

PYTHON CODE STRUCTURE

FUNCTIONS:

A. FE_Amplification(I_1PE, time, params)

Depend on the FE Transfer Function: 3 options available, selected with the class inizialization

Regulated Common Gate Amplifier

$$\frac{V_{out}}{I_{in}} = \frac{R_L}{\left(1 + s\frac{C_T}{gm1A}\right)(1 + sC_L R_L)} \cdot G$$

Regulated Common Gate Amplifier with pole in the boosting fb loop

$$\frac{V_{out}}{I_{in}} = \frac{R_L gm1 A_0}{(C_T \tau_R s^2 + C_T s + gm1 A_0)(1 + sC_L R_L)} \cdot G$$

Regulated Common Gate Amplifier with pole and zero in the boosting fb loop

$$\frac{V_{out}}{I_{in}} = \frac{R_L gm1 (A_0 - C_{gd} R_R s)}{(R_R C_T (C_{gs} + C_{gd}) s^2 + C_T s + gm1 A_0)(1 + sC_L R_L)} \cdot G$$

BEHAVIORAL MODEL

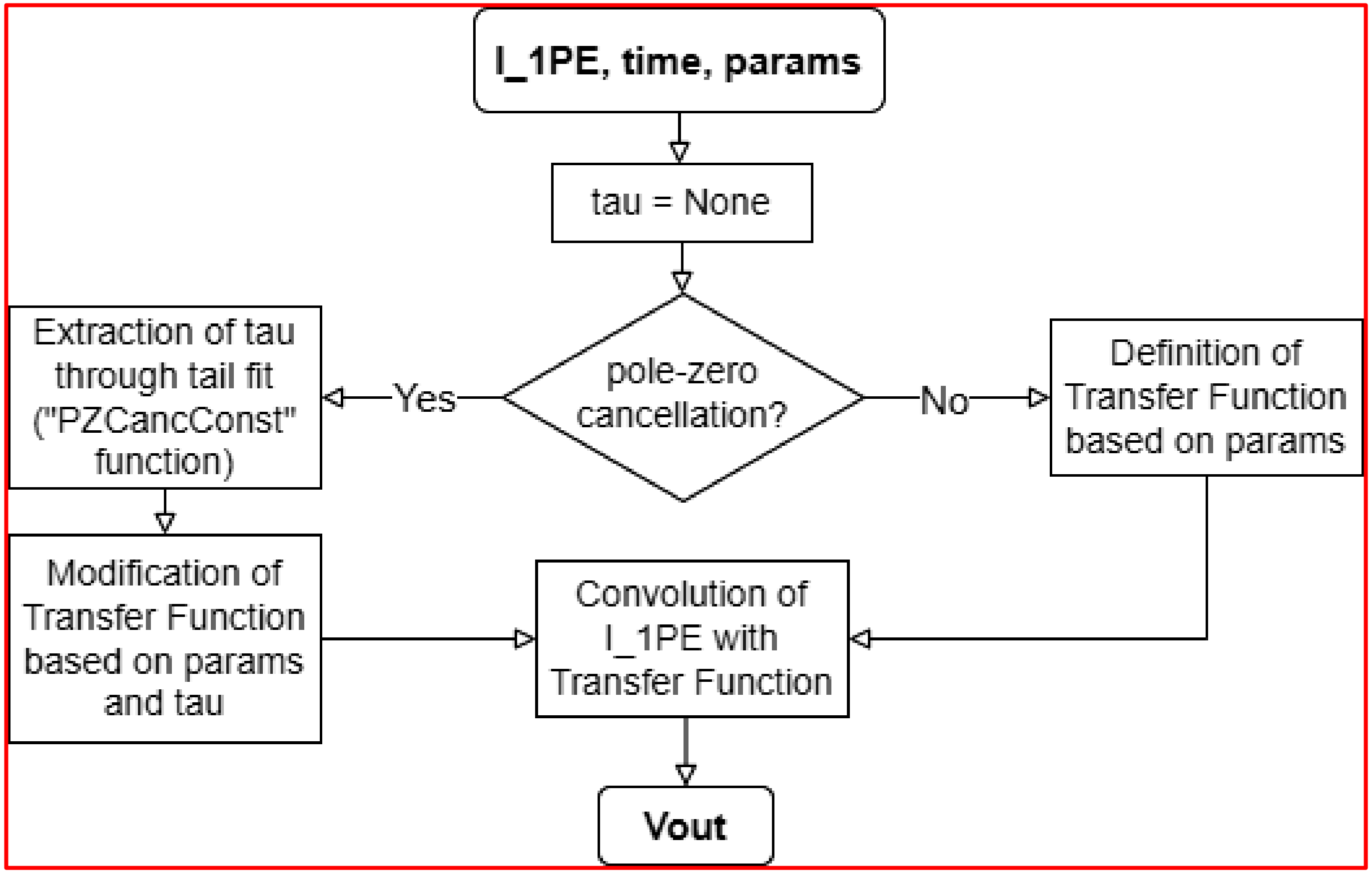
PYTHON CODE STRUCTURE

FUNCTIONS:

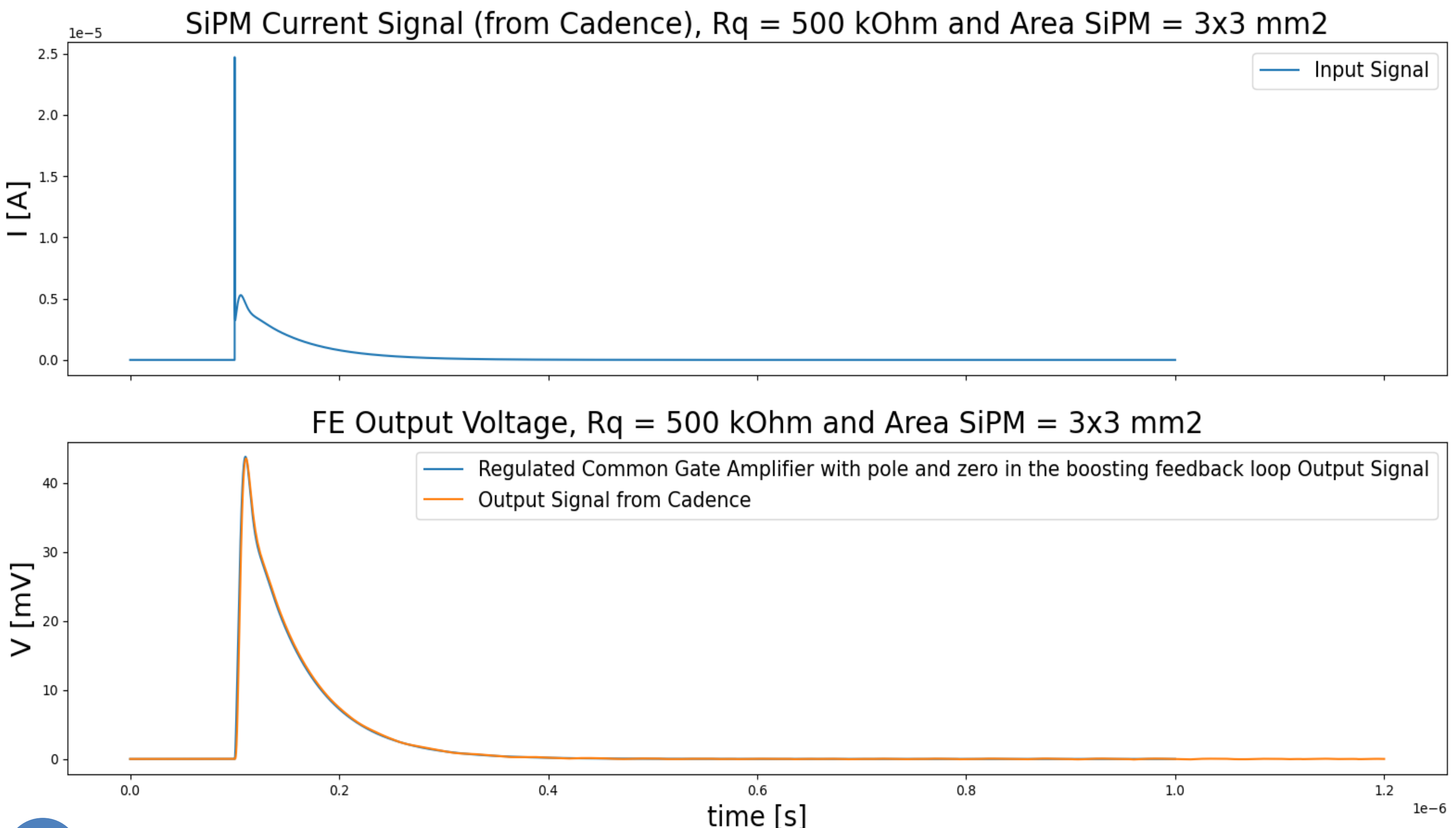
A. FE_Amplification(I_1PE, time, params)

Based on function:

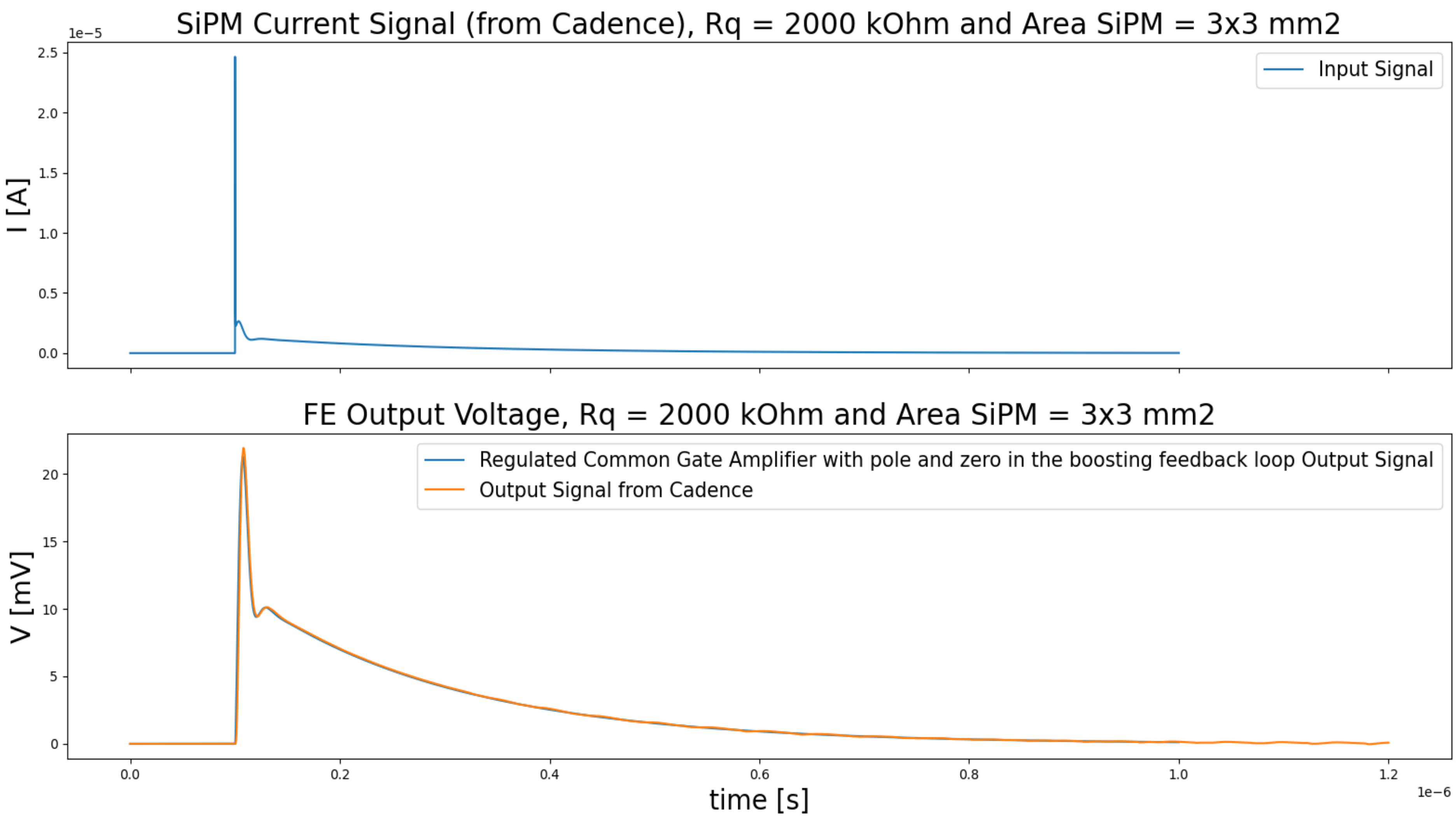
FE_Convolution (I_1PE, time, params)



BEHAVIORAL MODEL



BEHAVIORAL MODEL



BEHAVIORAL MODEL

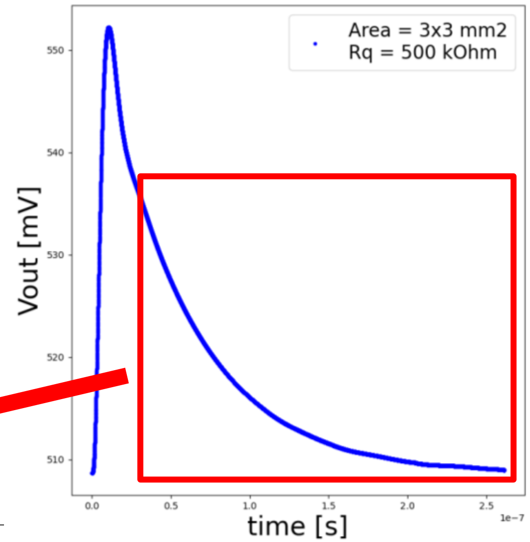
PYTHON CODE STRUCTURE

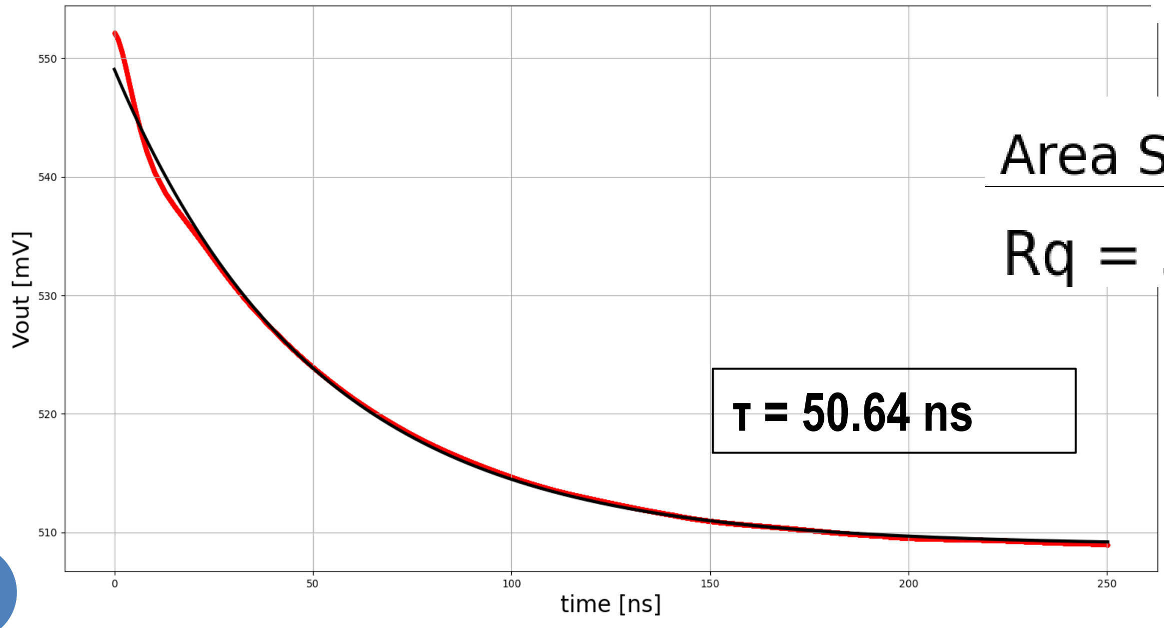
FUNCTIONS:

B. POLE-ZERO CANCELLATION: a first valutation of the pole

TailTimeConstFinder(Vout, time)

$$V_{out} = A \cdot exp\left(-\frac{t}{\tau}\right) + B$$





Area SiPM = 3x3 mm2

Rq = 500 kOhm

τ = 50.64 ns

BEHAVIORAL MODEL

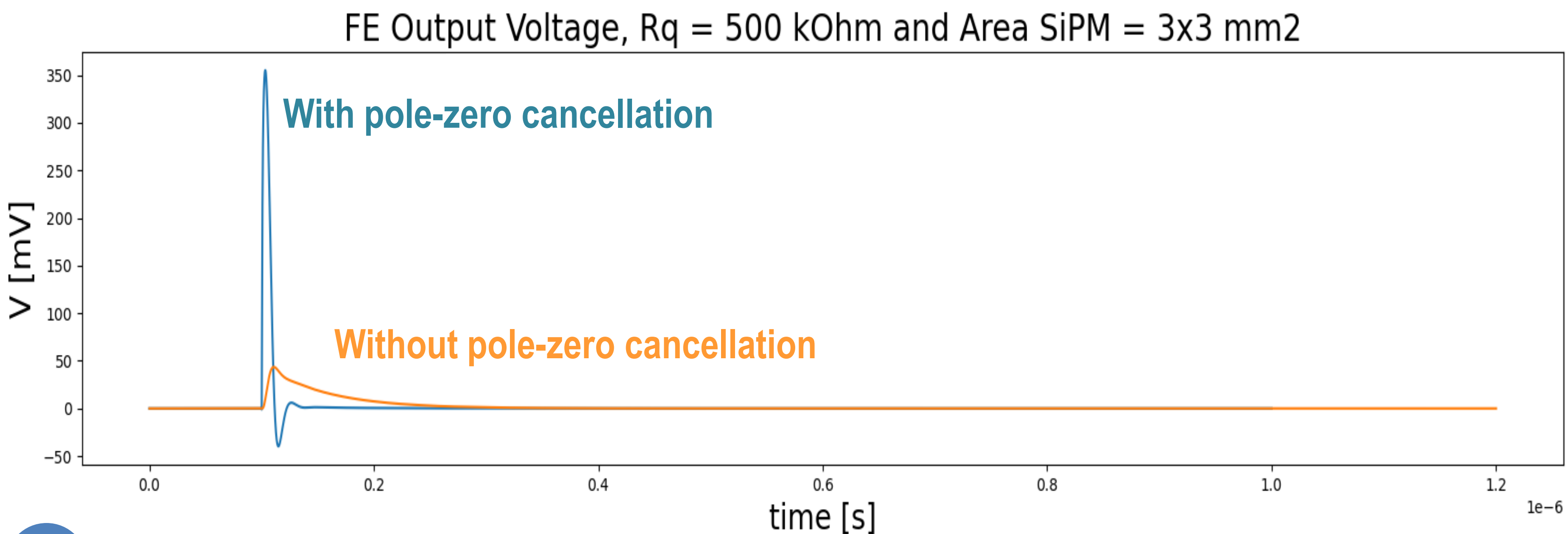
PYTHON CODE STRUCTURE

FUNCTIONS:

B. POLE-ZERO CANCELLATION: modification of the FE Transfer Function

ZeroMult(num, tau) → $$T'(s) = T(s) \cdot (1 + s\tau)$$

With: $$T(s) = \frac{num}{den}$$

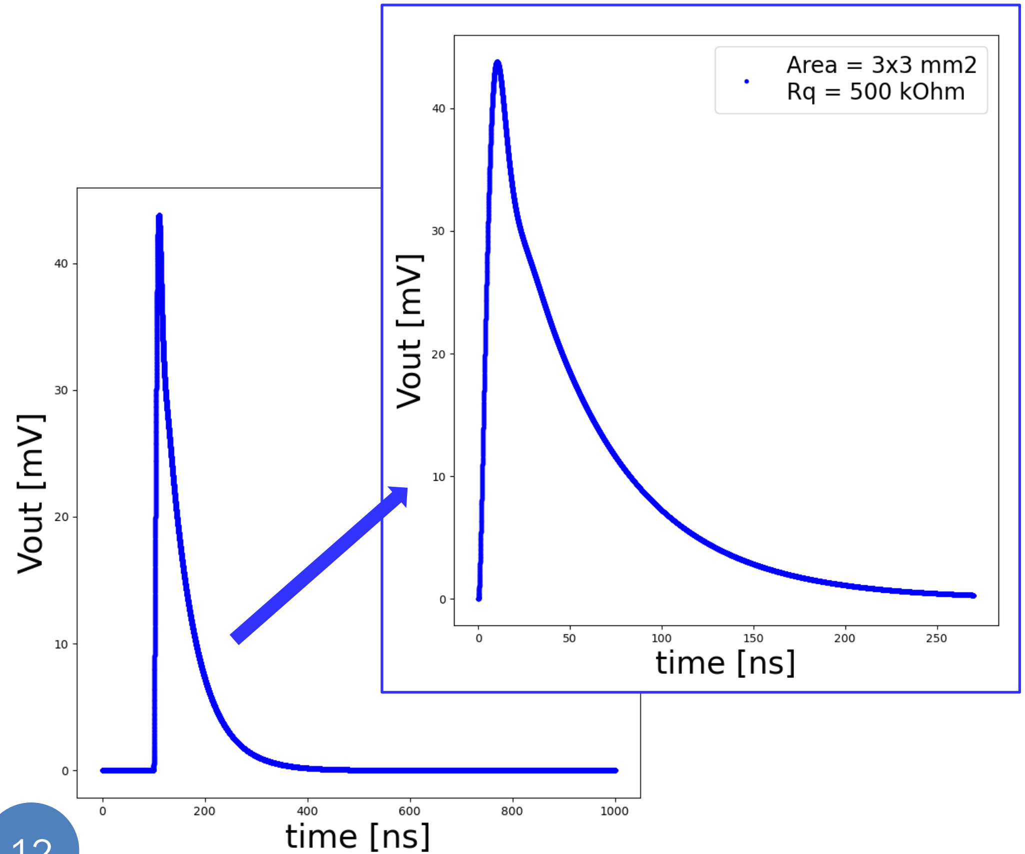


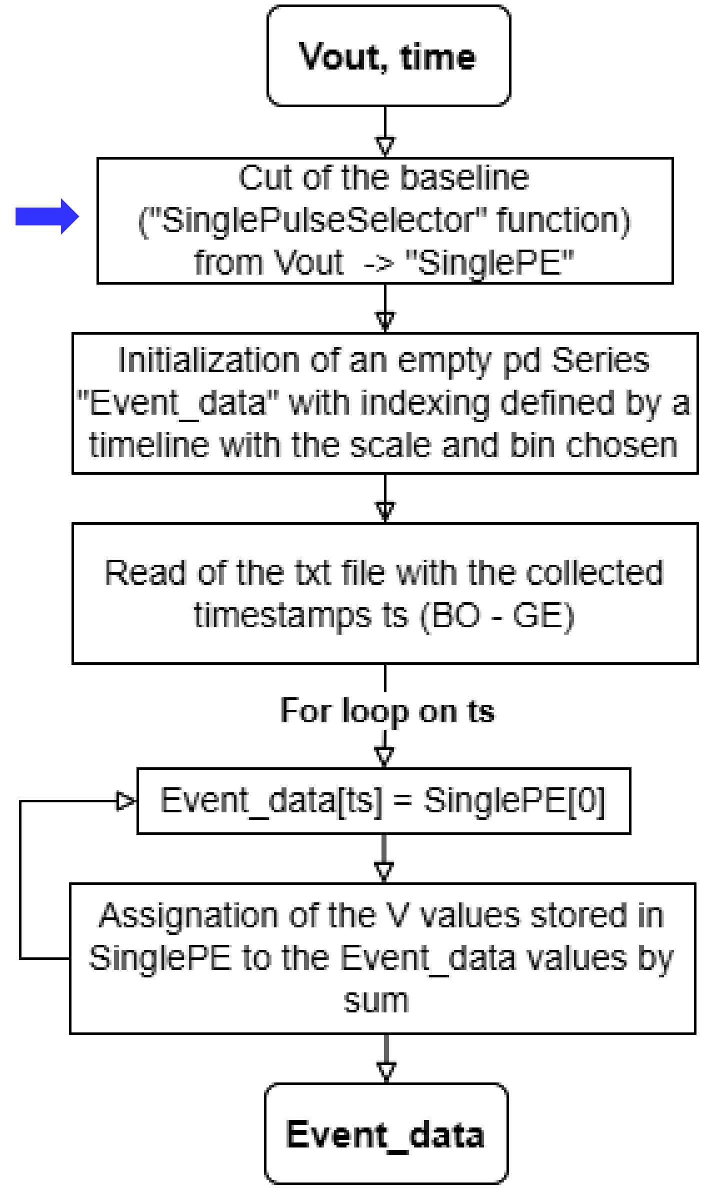
BEHAVIORAL MODEL

PYTHON CODE STRUCTURE

FUNCTIONS:

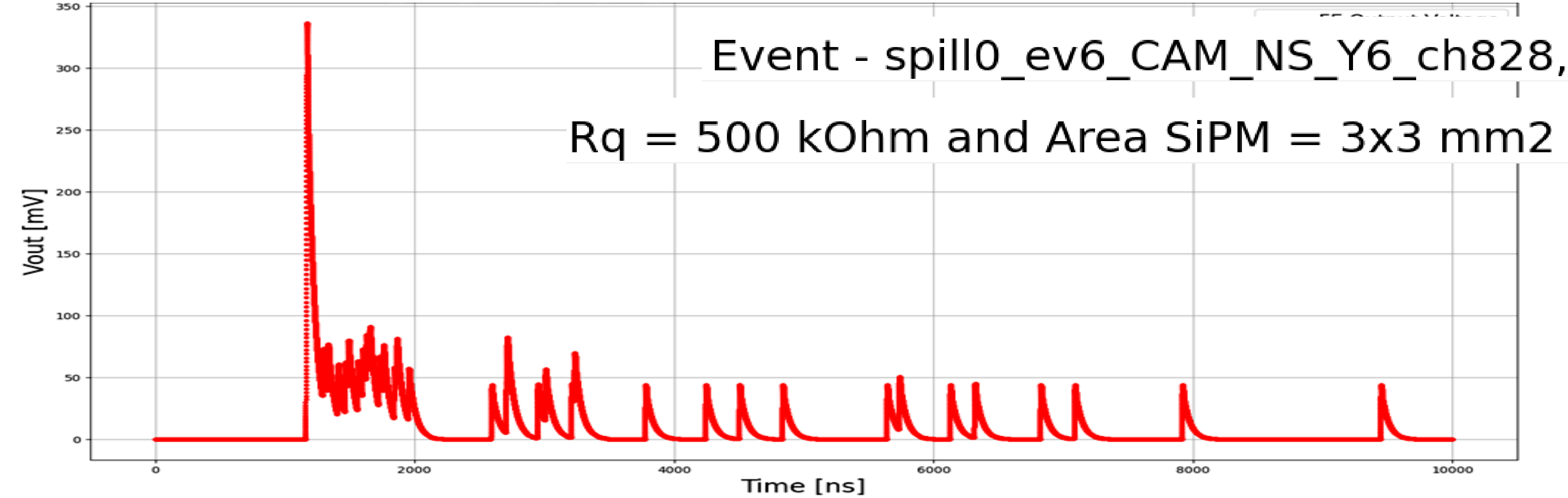
C. EventConstructor(Vout, time)

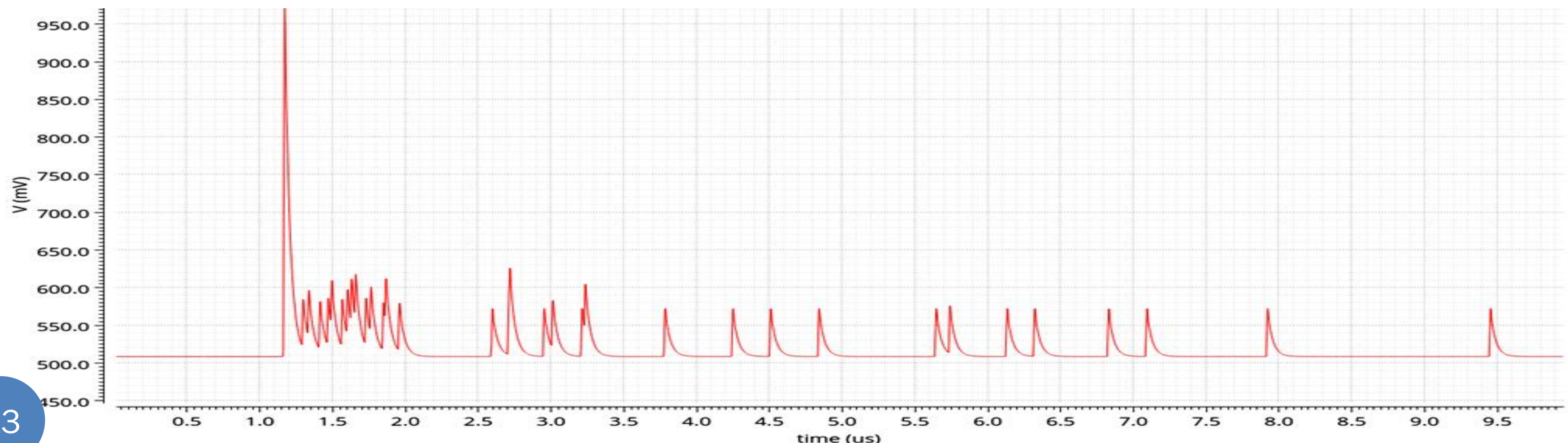




BEHAVIORAL MODEL

REPRODUCTION OF A SPILL USING THE PROCESSED SIGNAL WITH A BINNING OF 100 ps





BEHAVIORAL MODEL

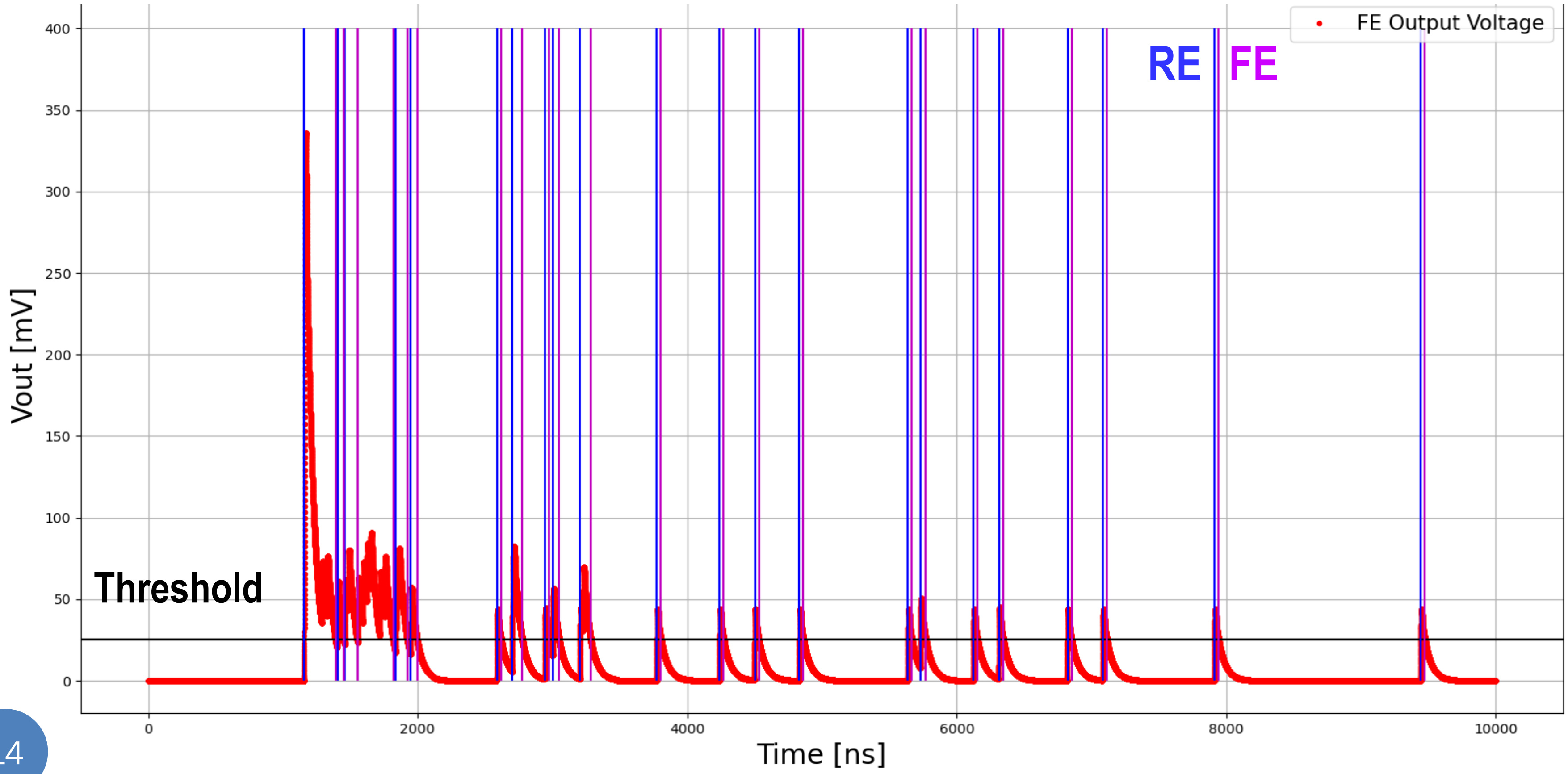
PYTHON CODE STRUCTURE

FUNCTIONS:

D. Discriminator(Event_data, Vth, Hyst)

Threshold

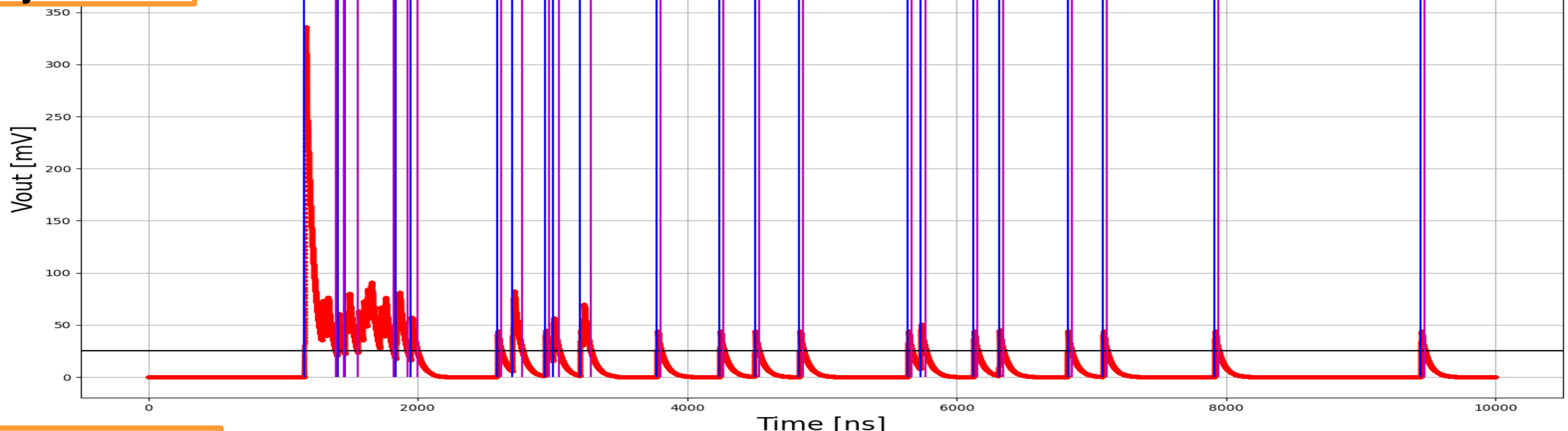
Hysteresis



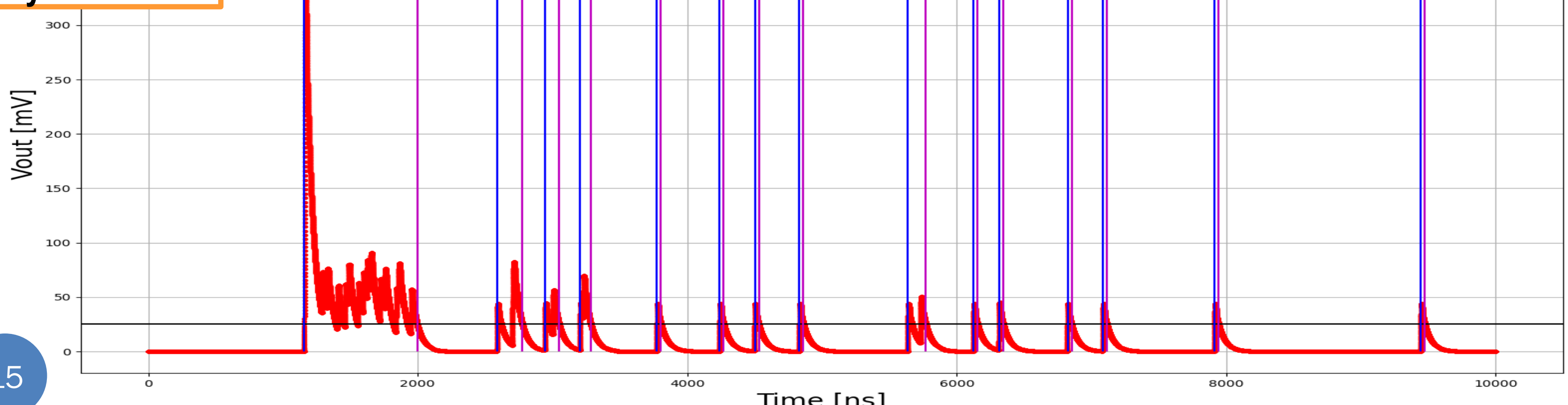
BEHAVIORAL MODEL

DISCRIMINATOR WITH DIFFERENT HYSTERESIS

Hyst = 0 ns



Hyst = 100 ns



NEXT STEPS

- Tuning of Pole 0 Cancellation
- Analysis of the different combinations of Rq and Area

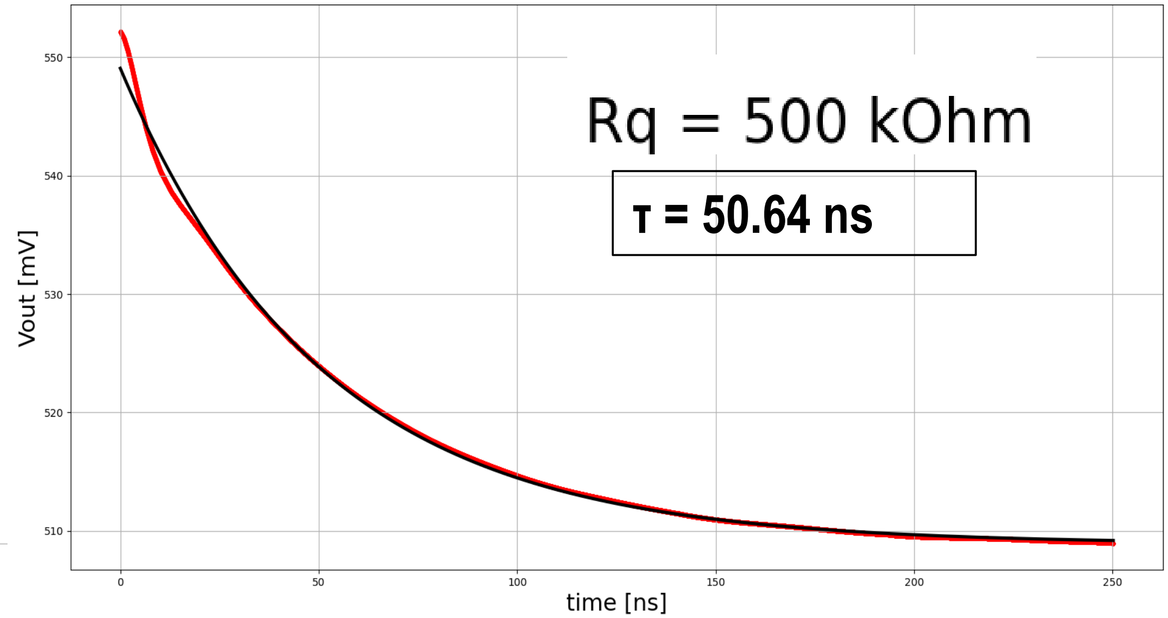
BACKUP SLIDES

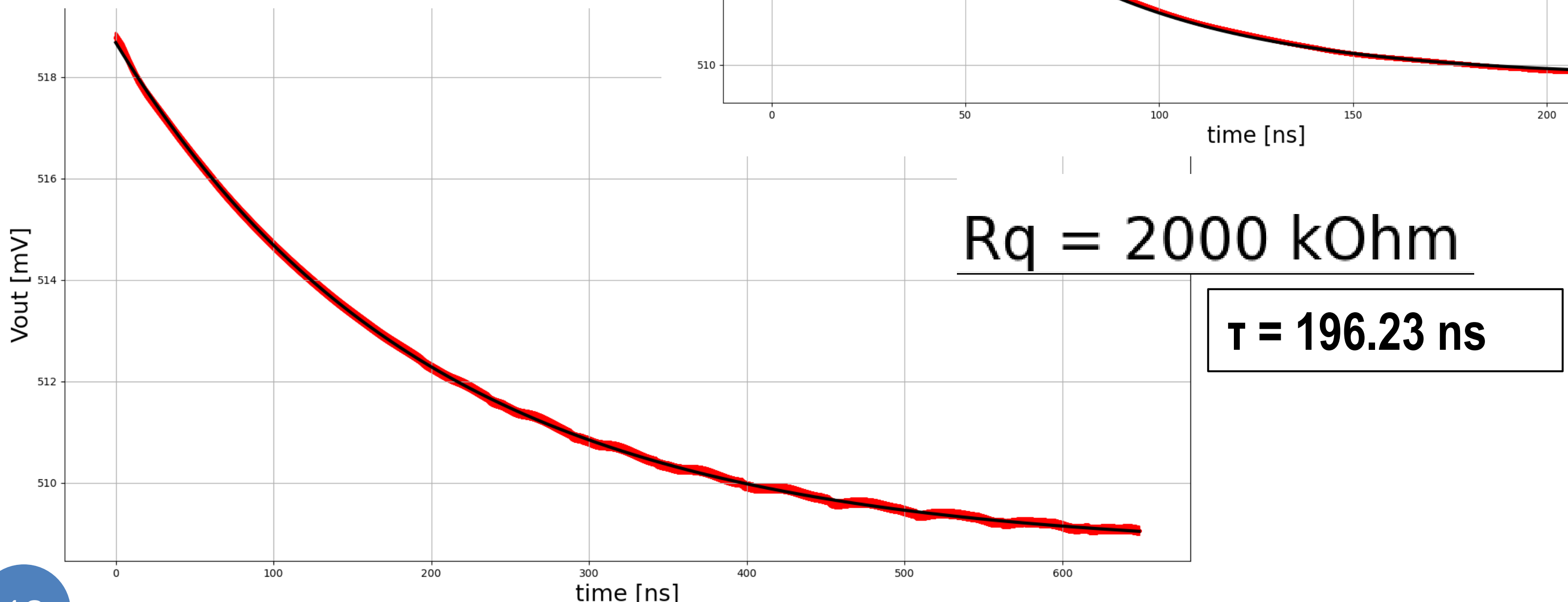
BEHAVIORAL MODEL

PYTHON CODE STRUCTURE

TailTimeConstFinder(Vout, time)

Area SiPM = 3x3 mm2





BEHAVIORAL MODEL

Bode plot